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MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

VOLUME XX

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OF THE

MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. McCARTNEY
UNIVERSITY OF MICHIGAN

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VOLUME XX

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."
— SENECA, *Naturales Quaestiones*

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AN EXPERIMENTAL STUDY OF THE TECHNIQUE OF INDIAN POTTERY MAKING

JAMES B GRIFFIN AND CARLETON W ANGELL

RECENT research work in the Ceramic Repository in the University of Michigan Museums revealed that a more complete understanding of Indian pottery could be gained by a better knowledge of the materials used by aboriginal artisans and of their methods of constructing the vessels For this reason the experiments discussed below were undertaken The methods employed followed as closely as was deemed necessary the procedure of the primitive craftsman The ceramic specimens from the eastern half of North America and, more particularly, from the northern part of that area appear to be of rather crude and primitive workmanship It would not seem that much skill or technical knowledge would be needed to duplicate the results obtained by Indian potters However, we found that there were a number of tricks to this trade with which we were not familiar and that our work was merely a small beginning in the amount of technical investigation which will have to be done before this phase of aboriginal industry is understood

During the summer of 1933 we spent two weeks at the University of Michigan Fresh Air Camp located on Patterson Lake, Livingston County, Michigan, at which time we carried out the investigations We should like to thank the Board of Directors of the camp and particularly the director, Mr George Alder, for the many favors and courtesies extended to us during our stay at the camp

The clays used in the experiment came from beneath the director's cottage, from a road bank at a small community that is locally called "Hell," and from a deposit of native commercial clay at Flint, Michigan. These clays were selected because we wished to observe the different reactions of unworked clay and the commercial product The grit temper was obtained by crushing partially disintegrated granitic firestone which came from a neighboring Indian site Sand was secured from the camp supply Shells for tempering

were fresh-water bivalves gathered in Patterson Lake, they were identified by Dr Henry Vander Schalie as *Anodonta grandis footiana* Lea and *Lampsilis siliquoidea* Barnes The clay, shell, and rock were pulverized in an iron mortar and pestle By varying the amount of the tempering material used with the clay we sought to discover the proportions employed in aboriginal times Other material included cloth, saucers, a zinc-lined table, a wire screen, walnuts, a corncob, a cord-wrapped stick, a cord-wrapped paddle, a paddle with a carved design, a smooth paddle, and several water-worn pebbles The pottery was made under the shade of a large walnut tree, so that the heat of the sun would not dry the clay as it was being shaped

After the assembling of the materials the first step was the preparation of the ingredients The individual clays were placed one at a time in the mortar and pulverized The aboriginal custom was to crush the clay between stones It was then sifted through a ⅛-inch screen and placed on the table Some of the tribes winnowed the clay to remove impurities, but others were not so particular The shells were scraped to remove any foreign matter and were pounded into small pieces The rotten rock was subjected to the same pulverizing treatment

A sufficient amount of clay to make three or four pots from 4 to 6 inches in diameter and from 4 to 5 inches high was mixed with approximately one third or one fourth as much shell or grit The materials were not weighed because of the loss resulting from blending the mixture, molding the pot, and scraping and smoothing the unfinished vessels It was thought that the more accurate knowledge of the exact percentages of clay, temper, and water in the vessel would not be worth the expenditure of more time and labor The clay-temper mixture was then formed into a circular dam, and a small quantity of water poured into the center The water was worked into the mixture until the clay had the consistency of thick dough (see Pl I, Fig 1) If the mixture was too dry, the clay could not be worked, if it was too wet, the hands became encased in the clay When the clay had been thoroughly kneaded, it was placed to one side and covered with a damp cloth to prevent evaporation of the water

A square of the cotton cloth saturated with water was laid on the concave surface of a saucer This practice is closely analogous

to known procedure of Indian potters, as is the following method of construction A small amount of clay from the kneaded mass was rotated between the palms of the hand and formed into a ball This ball was then placed on the cloth and squeezed out over the surface of the saucer to within a half-inch of the lip The edge of this basal pat was beveled upward and inward to form a base for the first clay roll More clay was taken from the mass and rolled between the hands, or on the table, into a ropelike strip having sufficient length to encircle the pat just completed This rope of clay is called the coil The beveled edge of the pat was moistened before the coil was applied, as was each succeeding surface to which clay was added The coil was held in one hand while the other hand attached it to the prepared surface (see Pl I, Fig 2) The tips of the fingers were used to press the coil firmly to the preceding layer of clay Immediately after applying each circle of clay, the inner and the outer projecting portion of the coil was pressed down over the preceding one, forming a smooth surface It was found that, with the size of the tempering particles used, the right thickness of the walls of the vessel could be obtained while the clay was still plastic If an attempt was made to scrape the walls to their proper thickness after the vessel had dried, the temper particles were often pulled from the surface, leaving a hole in the wall If these surface cavities were filled in, care had to be taken to remove completely any air within, otherwise the vessel would break while being fired

By the time the last coil had been firmly applied the pot had assumed a finished appearance, for the thickness of the walls had been set If the rim was to be a distinct feature, an added coil was blended upon the outer surface of the preceding coil and the joint smoothed (see Pl I, Fig 3) Scallops on the lip were produced by simply holding the palm of the left hand against the inner wall while the index finger of the right hand pressed firmly against the lip

A variety of surface markings was obtained with the use of bark and dried walnuts, which were pulled across the surface The corncob and the cord-wrapped paddle were rolled across the wet clay, and the cord-wrapped paddle was also used to malleate the surface The design on the carved paddle was stamped into the surface of one of the vessels (see Pl I, Fig 4) The smoothing pebbles and the paddles were used to produce an even surface finish

The pot was now ready to be dried It was placed in a shaded

spot where it would not dry too rapidly and crack The time needed for drying depends on the weather and the thickness of the vessel It is absolutely necessary that there should be no moisture in the clay when the vessel is fired, otherwise it will disintegrate

A small wood fire was prepared, and the dried pots supported by sand were set up around it, with the mouths of the vessels toward the flames (see Pl II, Fig 1) When the fire had burned down to coals, the vessels, which were now too hot to handle without gloves, were laid on the embers mouth downward Dried cow dung and bark were placed over the pottery and allowed to burn away The completed vessels were then permitted to remain in the ashes in order to prevent breakage from uneven cooling The initial heating averaged twenty to twenty-five minutes, with the actual firing taking a half-hour more The fired vessels were left in the coals for over two hours, and when finally removed were still warm

Of the vessels that have subsequently been broken and examined two were made of clay from Flint, Michigan, which had been mixed with sand approximately in the proportions of 2 to 1 The hardness of these vessels and of the others is from 2 to 2 5 The texture of the paste is fine The clay before firing was gray These two vessels burned to a very light brown on the exterior surface The cross-sections revealed that the brownish color extends but a short distance into the body, varying from a mere film to approximately one fourth of the thickness of the cross-sections

Some authorities believe that it is possible to ascertain the method by which a pot was formed by examining the broken pieces We know that these vessels were constructed by coiling, and according to this theory should have broken primarily along the coiling lines The two vessels discussed above and all the others save one broke perpendicularly to the coiling lines

Another combination was made of two parts of Flint clay to one of grit or pounded rock The texture of this group is medium-fine Here also we see the change of color from the original gray to a brown on the exterior surface The cross-section, however, presents a somewhat different picture The line of separation between the inner grayish zone and the brownish exterior is sharply marked, so that the vessel appears to have been made from two different clays

Firing the Hell clay resulted in a change from the original light yellow to a light brown on the surface and to a grayish brown in

the cross-section This clay shows a tendency to surface-crackle in restricted areas

One of the vessels was made of light yellow clay taken from beneath the director's cottage and shell was used as the tempering material The color before and after firing was nearly the same as that of the Hell clay Much of the shell that was exposed on the exterior surface, or that which lay close beneath the surface, was slaked, it appears as white spots on the photograph (see Pl II, Fig 2) The shell in the rest of the vessel was not affected in this manner

The surface of the vessel that had been smoothed with a paddle did not show to a noticeable degree the individual strokes used, but the horizontal markings left by the smoothing pebble were quite distinct This type of smoothing is very often encountered on Indian pottery of eastern United States The impressions left by the cord-wrapped paddle are identical in type with some of those appearing on eastern Woodland pottery (see Pl II, Fig 3) The design made by the carved paddle (see Pl II, Fig 3) is analogous to a type of surface decoration common in southeastern United States

This preliminary investigation has produced a number of rather interesting results Pottery made from unrefined native clay is as hard as that made from refined native clay when the two are fired in the open air Most of the Indian pottery of the neighboring regions contains a higher percentage of tempering material than was used in these experiments Vessels made of clay from a given deposit will, in general, assume the same color pattern, but individual variation owing to different firing conditions is liable to be greater than might be supposed Distinctly defined color differences between the surface and the interior of a vessel are not conclusive evidences of a slip, since the color difference is not an adequate criterion The determination of the method of constructing a vessel by the fracture lines is liable to be inaccurate unless, for instance, the lines of coiling have not been obliterated A surface finish similar to that of aboriginal vessels can readily be duplicated today

Future work will attempt to arrive at more accurate determinations of the percentage of tempering used We should like to know the amount of heat and the length of time needed to fire a given clay to a given hardness We should also like to know the method by which the Indians avoided the slaking of the shell employed in

tempering while obtaining a harder vessel than we produced We shall also attempt detailed examinations of sherd cross-sections in an endeavor to determine the method of construction There are, of course, many questions yet to be answered concerning the nature of the materials and the technique of manufacture of Indian pottery A trained ceramist is at present devoting his time to detailed physical analyses of the primitive wares in the Ceramic Repository As time goes on our studies of aboriginal pottery not only will contain accurate descriptions of the specimens, but also will carry objective data on their physical properties

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PLATE I

FIG. 1 Mixing moistened clay with the tempering material

FIG. 2 Placing the first coil on the basal pat

FIG. 3 Rolling the rim

FIG. 4 Applying the stamped design

PLATE II

Fig 1 Arrangement of pottery preparatory to the initial heating

Fig 2

Two thirds Hell clay and one third grit Surface malleated with cord wrapped paddle

Two thirds unpurified clay and one third shell Surface smoothed with smooth paddle

Fig 3

Two thirds Hell clay and one third grit Stamped decoration

Two thirds flint clay and one third sand Surface impressed with cord wrapped paddle

GOLD-DECORATED TEETH FROM THE PHILIPPINE ISLANDS

CARL E GUTHE

THE Philippine collections of the Museum of Anthropology of the University of Michigan contain a group of forty-three human teeth possessing small holes into which gold disks or plugs were inserted for decorative purposes These are all anterior teeth, with the holes drilled on the labial or outer surface In twenty specimens the gold disks are still in place, and four of them bear gold plates which are attached to the surface of the tooth by means of minute pins, similar to the plugs There is every reason to believe that the Filipinos obtained the gold used in this manner by placer mining in some of the Philippine streams from which gold may still be obtained today

These examples of an unusual method of adornment were obtained by the 1922–25 archaeological reconnaissance expedition sent by the University to the southern half of the Philippine Archipelago They were originally associated with burials located in three widely separated parts of the Visayan, or central, group of islands, namely, the islands of Negros, Masbate, and Samar

The Honorable Dean C Worcester, who sponsored the expedition, turned over to its collections a group of material obtained during excavations carried on under his direction prior to the arrival of the expedition. At one of these sites, bearing the field catalog number B 1, two teeth were collected, each of which had gold plugs in its labial surface The site was a burial ground or cemetery on a sandy beach about three miles south of the town of Vallehermoso, in the northern part of the province of Eastern Negros No detailed record had been kept of the contents of each grave, but the cemetery as a whole yielded many examples of trade materials, such as Asiatic porcelains and stoneware; glass, stone, and gold beads of several varieties, lead net sinkers, and a specimen of iron, and, in addition, native pottery and ornaments.

Teeth ornamented with gold were found in two localities in the municipality of Aroroy, in the extreme northwestern tip of the island of Masbate The first of these (G 91) was a burial found by a Filipino in 1923 while digging a post hole for a house It was in a sandy beach between Diablo Island and Point Colorado, about one hundred yards from the water line The bones of an adult had been buried in a jar bearing a brownish green glaze and ornamented with a dragon design Above the jar, which had been placed right side up, were found the fragments of a celadon bowl, which once may have served as a cover Under the jar was a light-colored stoneware bowl, on which was a badly disintegrated glaze The four upper incisors of the burial had had gold plugs in them The Filipino discoverer tore out sixteen disks from two of them, but the other two still retain seven disks each

The second locality in Masbate was near the town of Malibon, only a few miles from the site of the burial just described In a small cave, which is little more than a rock shelter (C 47), badly shattered human bones indicated former burials Rotting fragments of a small wooden coffin of native workmanship, sherds of native-ware jars, of a large glazed jar with a dragon design upon it, and of monochrome glazed stoneware bowls were scattered on the surface of the cave floor Screening the deposits in several sections of the cave revealed antler points, bone beads, a thin gold disk with an embossed design, and seventy miscellaneous human teeth Three of these teeth had been ornamented, one bore an empty hole on its labial surface, but two others still carried irregularly shaped thin disks covering the entire labial surfaces

The great majority of the teeth bearing gold decorations, that is, thirty-four out of forty-three, were encountered while screening the deposits in two burial caves on small islands just off the west coast of Samar, lying east of the small island of Daram, and thirteen miles due south of the town of Catbologan One of these (C 2), which was examined by Mr Worcester's party, yielded sixteen such teeth, the second (C 7), dug by the expedition, revealed eighteen teeth ornamented with gold Although the first cave was much larger than the second, the conditions and associations in both, which were in limestone formations, were essentially the same The floors, although usually dry, had clearly been subjected to water action, probably during storms The confusion resulting from natural dis-

turbances was increased by occasional visits of beasts and men. The bones of the skeletons had been scattered. In the second cave three human skulls were seen jammed in a crevasse. Fragments of the same vessel were found separated by many feet, and sherds, apparently old, lay beside more recent ones, in the relatively shallow deposits which had no clear stratification. The caves had apparently been used a long time as places of burial, for the collections, obtained largely by screening the deposits, include, in addition to the ornamented teeth and other skeletal remains, the following materials: fragments of stoneware and earthenware plates and bowls, some bearing monochrome glazes of green, gray or brown, others showing blue and white or black and white designs, sherds of greenish brown glazed jars, and of native-ware vessels, a few iron implements, and handles made from antler fragments, and articles of adornment, including bracelets, rings, and beads of shell, stone, and gold. Among the hundreds of disassociated human teeth were many that were discolored, probably largely by betel-nut stain. Others showed evidence of having been filed, either to bring them to a point, or to flatten their labial surface.

The evidence indicates that Visayan Filipinos, living in at least three widely separated localities, had formerly mutilated their teeth for purposes of adornment by staining them, by filing them in two ways, and by inserting gold plugs or disks into the labial surfaces. The last custom is not necessarily confined to a single cultural group, for it has been found associated with three forms of burial: simple inhumation, cave burial, and jar burial. It is unfortunate that the confused condition of the cave deposits did not permit the stratigraphical dating of this custom. It may be noted in passing that some of the associated Chinese trade vessels appear to have been made during the Sung dynasty (960–1279 A.D.)

We have documentary evidence, however, that the Filipinos decorated their teeth in this manner not many centuries ago. Antonio Pigafetta, the Italian chronicler of Magellan's voyage, wrote that in March, 1521, the company stopped at Butuan and Caraga, in northern Mindanao, where they met a native chief who "had three spots of gold on every tooth, and his teeth appeared as if bound with gold."[1] In a letter from Seville, written about 1564–65, mention is made of decorating teeth. "By way of adornment, they color their

[1] Blair and Robertson, 33: 123.

teeth, and bore them through from side to side, placing pegs of gold in the holes "[2] A Jesuit monk, Pedro Chirino, who lived in the Philippines from 1590 to 1635, wrote in his *Relación*, which was published in Rome in 1604 "They [the Filipinos] all cover their teeth with a varnish, either lustrous black or bright red — with the result that the teeth remain as black as jet, or red as vermilion or ruby From the edge to the middle of the tooth they neatly bore a hole, which they afterward fill with gold, so that this drop or point of gold remains as a shining spot in the middle of the black tooth This seems to them most beautiful, and to us does not appear ugly "[3]

Morga, in his *Sucesos*, which was published in 1609, gives additional information "All are very careful of their teeth, which from a very early age they file and render even, with stones and iron They dye them a black color, which is lasting, and which preserves their teeth until they are very old, although it is ugly to look at "[4] Father Diego de Bobadilla, in an unsigned and undated manuscript, which was probably composed during the years 1638–40, states that the Filipinos "file them [their teeth] from their earliest childhood, some making them even in this way, others filing them into points, thus giving them the appearance of a saw They cover the teeth with a black, glossy polish, or one that is flame coloured, and thus their teeth become black, or as red as vermilion In the upper row, they make a little covering which they fill with gold, which shows off to advantage on the black or red background of that polish "[5] Before the middle of the eighteenth century the Filipinos seem to have abandoned this custom, for a Franciscan monk, Juan Francisco de San Antonio, says in his *Cronicas*, which was published at Manila between 1738 and 1744 "They also, especially the chief women, adorned the teeth with gold, with exquisite beauty I do not know whether they waste the gold so now "[6]

That an interest in this form of personal adornment still persists among the Filipinos in the twentieth century is indicated by Dr Louis Ottofy, of Chicago, who practiced in Manila during the early days of the American Occupation He has sent the following statement "The desire for ornamentation was so keen that there was devised a so-called dental ornament This consisted of a thin piece of gold, about eighteen carat, cut in the shape of a heart To its distal sur-

[2] Blair and Robertson, 2 223
[3] *Ibid*, 12 187
[4] *Ibid*, 16 78
[5] *Ibid*, 29 287–288.
[6] *Ibid*, 40: 327

face two small lugs were soldered These passed in the interproximal space between two incisors, or the lateral incisor and the cuspid (but generally between the central incisors), the lugs were then bent with the fingers, one to the right, the other to the left, and the piece of gold was held in place From a distance the appearance was that of large gold fillings in the proximal surfaces The piece could be removed by the wearer, and when tarnished, could be polished and replaced Or if one was tired of wearing it in one place, it could be moved elsewhere I was informed that on special occasions, such as a wedding or a fiesta, the principals would borrow these ornaments from their friends, and thus exhibit a number of them in the same mouth, giving the appearance of many gold fillings Later, when gold crowns began to be seen, this practice of ornamentation was extended and a piece of gold was cut to cover the entire labial surface of the tooth, with two projections or lugs which passed between the interproximal surfaces on each side, and being bent on to the distal surface of the tooth, held it in place In eating, food wedges between the tooth and the gold ornament or fácing, but as they can be taken off at will, they are washed and replaced These ornaments and facing were also made and adjusted by jewelers The usual price was three pesos for the ornament and five pesos for the facing Since the introduction of gold crowns, and the increase in the number of dentists in all parts of the islands, this practice is being abandoned in favor of gold crowns "

Yet the custom of mutilating teeth for purposes of adornment seems to have disappeared in the Philippines before any known careful record was made of the process by which the disfigurement was accomplished Fortunately, travelers of recent years in other islands of Malaysia have described a still existing identical custom among the inhabitants of Borneo and Sumatra, with the single difference that brass was used instead of gold Dr Joseph B Davis, in the catalog of his collection of skulls, describes and illustrates a skull of a young Dyak man, named Pa-Handoeran, about thirty years old at the time of his death, which came from Bandjermassing, on the island of Borneo · "The teeth have been fearfully tampered with at the dictation of fashion Both upper and lower front teeth have been rubbed down on their cutting-edges, the first considerably, then the four upper incisors and two canines have been tapped with a small hole through the enamel and into the cavity of the tooth (on their front

surfaces), and a metallic peg with a round head driven into each In this way (when the upper lip was raised) the shining knob on each tooth would be displayed The metal is yellow, and no doubt it is brass The pegs of the outer incisors have fallen out, and the holes pierced into their pulp-cavities are seen "[7]

H Ling Roth,[8] who wrote a large treatise called *The Natives of Sarawak and British North Borneo,* gives a number of illustrations of teeth filled with metal, and quotes from several sources, as follows "The Rev F W Leggatt informs me ' Teeth are also frequently filed like the teeth of a saw, and blackened, after which brass wire is cut into short lengths and driven in as studs into holes previously drilled in the teeth Or the stud ornament may be adopted without filing the teeth ' At Lake Padang Mr Hornaday 'took advantage of their good humor to ask them about the little metallic plates on some of their front teeth, which looked like gold I found that each upper incisor and canine tooth was capped by a smooth plate of copper, held in place by a pin driven into a hole in the tooth The Dyaks showed me how the hole is drilled (with a bow), and one imitated the agony they endure during the operation He was a good actor, and his facial and bodily contortions and writhings excited roars of laughter ' From the Baram river Mr C Hose writes 'The teeth are filed by nearly all the races of Borneo at any age, and in many cases drilled with holes in which brass wire is inserted (J A I XXIII, 167) "

The most satisfactory description of the process by which these holes are drilled and then filled with metal is given by E H Gomes,[9] in *Seventeen Years among the Sea Dyaks of Borneo* "The teeth are often blackened, as black teeth are considered a sign of beauty The blackening is done by taking a piece of old coconut shell or of certain woods, and holding it over a hot fire until a black resinous juice exudes This juice is collected and while still warm the teeth are coated with it The front teeth are also frequently filed to a point, and this gives their face a curious dog-like appearance Sometimes the teeth are filed concavely in front, or else the front teeth are filed down till almost level with the gums Another curious way of treating the front teeth is to drill a hole in the middle of each tooth, and fix in it a brass stud I was once present when this operation was in progress The man lay down with a piece of soft wood between his

[7] P 289 Skull number 279 [8] 2 78. [9] Pp 38–39.

teeth, and the 'dentist' bored a hole in one of his front teeth The agony the patient endured must have been very great, judging by the look on his face and his occasional bodily contortions The next thing was to insert the end of a pointed brass wire, which was then filed off, leaving a short piece in the tooth, a small hammer was used to fix this in tightly, and, lastly, a little more filing was done to smooth the surface of the brass stud I am told the process is so painful that it is not often a man can bear to have more than one or two teeth operated on at a time"

A more emotional but less complete account of the process is given by W H Furness, 3rd "The Ibans [of Borneo], not content with blackening the teeth, actually drill holes through and through the faces of the six front teeth, and therein insert plugs of brass, whereof the outer end is elaborated into stars and crescents Then they finish up by filing the teeth to sharp points! No dentist's chair can hold a more hideous torture than this The drill, — usually no more delicate an instrument than the rounded end of a file, — bores directly through the sensitive pulp of the tooth, tearing and twisting a nerve so exquisitely sensitive that but to touch it starts the perspiration and seems the limit of human endurance, yet an Iban will lie serene and unquivering on the floor while his beauty is thus enhanced by some kind and tender-hearted friend Of course, the tooth dies and becomes a mere shell, tanned inside and out by repeated applications of the astringent blackening, the gums recede, exposing the fangs of the teeth and sometimes portions of the alveolar process, — I need not add that the mouth of a middle-aged Iban is anything but attractive

"The brass plugs can be inserted or removed at will When a young Iban lad whom I took with me as a servant to Singapore and Siam, noticed that the people in the streets stared at his bestudded teeth, he at once removed the brass studs and kept them carefully locked up in his private box" [10] It seems unlikely, in view of the description by Gomes and the condition of the teeth described in this article, that the plugs could always be removed at will

Alfred Maass, in his two-volume work on central Sumatra, testifies that this curious custom also existed recently in that island In describing a trip down one of the rivers he says "It being successfully accomplished, the captain's features lit up, and between his reddish

[10] P 157

brown lips flashed his teeth, decorated with small gold plugs Goldsmiths from Fort de Kock, who travel through the country, fashion such embellishments for one rupee (i e , one gulden or 1 69 marks) "[11] Later, while discussing the customs of the mountain people of the town of Taluk, on the Kuantan river in central Sumatra, he adds "Many people, as we know, have a partiality for decorating their front teeth with small plates of metal For this purpose dentists bore small holes in the teeth, which are filled with gold, copper or brass wire Still other people who believe they have teeth which are too long, have them sawed off, and filed with coarse and fine grained stones until a hole results, which is then also filled as described above Teeth treated in this manner serve as adornment "[12] But the custom does not seem to be widespread, for later, in describing the people of the upper Kampar valley, which is adjacent to that of the Kuantan, he does not mention this type of decoration

Although the custom of inserting plugs of metal in the teeth may not have been practiced by some of the Malay groups, it is evident, from its occurrence in Sumatra, Borneo, and the Philippines, that it was generally known throughout the Malaysian islands Von Ihering, in his monograph on the artificial deformation of teeth, refers to this custom in his argument against the indigenous character of tooth filing among the Malays He writes "It may be possible that this custom of pointing [the teeth], which I have found among the Papuans and Negritos, was originally foreign to the Malayan elements, although as yet no sufficiently exact reports are in hand That the usual deformation of the teeth now found in the Malayan area was not originally common to all the Malays is shown, in addition to the narrow limiting of the relief filing with pointing to some of the Sunda Islands, and the recurrence of the pointing among the Negritos of the Philippines, by the fact that another very peculiar custom, which is now known only from Borneo and the Celebes, was formerly in use in the Philippines, by which it is known that they were in former times the habitat of the now almost exterminated Negritos. It is the custom of boring a hole in the front of the upper incisors, and filling this with metal, gold whenever possible The use of gold as decoration for the teeth occurs moreover also in Sumatra, where dental crowns were made of sheet gold "[13]

The custom of mutilating teeth for purposes of adornment is

[11] 1 150 [12] P 373 [13] P 217

not confined to Malaysia A variety of forms of tooth filing occur in many parts of the world In New Guinea the natives file the teeth to points [14] In central Africa this method of filing is accompanied by other forms [15] At least two forms of tooth filing existed in Mexico, Central America, and various parts of South America [16] But the custom of inlaying teeth, as described in this paper, is by no means so wide in its distribution The only part of the world outside Malaysia in which it occurs is in southern Mexico, northern Central America, and northwestern South America (Ecuador) [17] In these regions the drilled holes were often of larger diameter than those here described, and in addition to gold the Indians also used polished stones and ores as material for the plugs

The large University of Michigan collection of teeth from the Philippines bearing gold disks or holes for their insertion warrants a detailed technical examination of the specimens [18] in order to determine (1) the variability of the methods used in carrying out the operative procedures preliminary to the actual insertion of the disks, (2) the exact method of attachment, (3) the character of the metal used, (4) the shape in which the metal was available, (5) the reason for the stains, (6) the effects which such mutilation may have had upon the teeth themselves, the underlying pulps, and the surrounding soft tissues and bone, and, finally (7) the effect of diet and the presence or absence of any methods of oral hygiene

In Plate III a photograph of each tooth from the labial aspect is shown In Plate IV an X-ray from the mesio-distal aspect is shown The teeth are arranged in the same order in both figures, starting with one at the upper left A few examples among these of conditions bearing on the questions raised will be discussed

Tables I and II contain a summary of the conditions and characters observed on each tooth In order to avoid undue repetition it may be said that with but one or two exceptions all the teeth are stained a light brown, presumably from the chewing of betel nuts The form of the anterior teeth is one which for the most part carries strong marginal ridges on the lingual surface, creating a modified

[14] Bene van Rippen, *d*
[15] M H Saville, Bene van Rippen, *a* and *c*
[16] Bene van Rippen, *b*
[17] *Ibid*
[18] The author is indebted to L F Rittershofer, D D S, of the Graduate School of the University of Michigan, for the detailed observations and measurements recorded in the tables He also prepared the descriptive text and the accompanying figures.

TABLE I

Description of the Teeth

R = right c = central
L = left l = lateral

Serial number	Catalog number	Name of tooth	Diameters in millimeters: Tooth crown: Mesio-distal	Diameters in millimeters: Tooth crown: Labio-lingual	Diameters in millimeters: Hole	Diameters in millimeters: Gold disk average	Plate thickness in mm
1	B 1-123	L c incisor	7.60	6.69	1.0	1.0	
2	B 1-123	R canine	8.84	9.11	1.5	1.0	
3	C 47-10	R c incisor	7.50	7.48	2.0		
4	C 47-9	L canine	7.40	7.23	1.8		0.15
5	C 47-9	R l incisor	5.30	5.15	1.5	1.5	
6	C 7-71	R 1st prem	7.37	8.64	1.0		
7	C 7-71	R canine	7.92	7.70	1.0	1.5	
8	C 7-71	L c incisor	7.88	7.11	1.2	2.0	
9	C 7-71	L l incisor	4.29	4.40	1.2	2.0	
10	C 7-71	R l incisor	5.86	5.83		1.0	
11	C 7-71	L c incisor	8.50	7.25	1.6	1.0	0.33
12	C 7-72	R c incisor	8.18	8.23	1.2		
13	C 7-72	L canine	7.64	7.80	1.0		
14	C 7-72	L canine	7.15	7.83	1.7		
15	C 7-72	R c incisor	7.43	7.31	2.2		
16	C 7-72	R c incisor	8.56	7.00	1.8		
17	C 7-72	R c incisor	7.84	6.78	0.8		
18	C 7-72	R c incisor	7.22	6.98	2.0		
19	C 7-72	L l incisor	6.20	6.58	0.9		
20	C 7-72	L l incisor	6.05	5.85	1.6		
21	C 7-72	R 1st prem	6.18	8.33	2.2		
22	C 7-72	L 1st prem	7.20	9.30	1.9		
23	C 7-74	L c incisor	7.33	6.83	1.5		
24	G 9-15	R canine	7.65	7.68	1.2	1.2	
25	G 9-15	R l incisor	6.25	6.39	1.2	1.4	
26	G 9-15	R c incisor	7.93	6.71	0.8		
27	G 9-15	L canine	7.71	7.97	0.8		
28	C 2-19	R canine	8.80	9.10	2.3		
29	C 2-19	R l incisor	6.70	6.20	2.3		
30	C 2-19	L c incisor	8.12	7.98	2.0		
31	C 2-19	R canine	7.40	7.18	1.2		
32	C 2-19	R c incisor	7.40	7.03	1.0		
33	C 2-19	R c incisor	8.60	7.15	1.0	1.0	
34	C 2-19	L canine	8.42	9.10	1.5	1.5	
35	C 2-19	R 1st prem	7.11	9.00	1.7		
36	C 2-19	L c incisor	7.40	7.00	1.8		
37	C 2-19	R canine	7.98	8.20	1.0	1.0	0.10
38	C 2-19	L canine	7.49	7.50	1.0		
39	C 2-19	R canine	8.04	8.00	1.4	1.4	
40	C 2-19	R canine	7.96	8.12	1.4	1.4	
41	C 2-19	L c incisor	8.75	8.21	2.2		
42	C 2-19	L l incisor	7.65	6.50	2.0		
43	C 2-19	R l incisor	6.70	6.43	1.0	1.0	

TABLE II

TIONS ON THE

ONS	Serial number of teeth																																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
s on crown	+	+	+		+	+		+	+	+			+	+		+	+	+	+		+	+	+	+			+	+											+		+		
s on root also				+			+				+	+														+					+			+			+						
Stained lightly	+	+						+	+			+	+	+	+		+		+	+	+	+		+	+	+	+	+			+			+	+	+		+			+		
Stained heavily			+	+	+	+	+			+						+		+					+						+	+		+	+				+		+	+		+	
Stained 2–3 mm. below cemento-enamel junction				+	+	+	+		+		+	+				+			+		+	+		+	+	+	+	+	+	+		+		+			+		+	+	+		
Stained 1–2 mm. below cemento-enamel junction	+														+		+	+		+			+										+		+	+						+	+
Contact points worn little																	+								+		+						+		+			+					+
Contact points worn severely	+	+	+			+	+	+		+	+	+	+	+	+	+			+		+	+				+		+	+	+		+		+			+		+	+	+		
Abrasion ending in enamel					+	+		+	+	+												+	+									+											
Abrasion ending in dentine	+	+	+	+			+				+	+	+	+		+			+	+	+			+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
Abrasion ending in pulp															+		+	+																									
Pronounced marginal ridges on lingual	+	+	+	+	+	+	+	+		+		w	+	+	w	+		w	+	+			+	+	+	+	+	+	+	w	+	w		+		w	w	w	+	+	w		+
bsorption																		+		+																							
ementosis																+							+						+							+					+		
MUTILATIONS																																											
urface filed flat	+		+		+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+	+				+		+	+		+	+	+					+	
urface filed concave		+																+									+	+	+					+				+	+	+	+		
lling ending in enamel	+		+	+		+				+	+	+	+	+	+	+			+	+	+	+	+				+	+		+	+	+			+			+				+	+
lling ending in dentine		+					+	+	+								+							+	+	+			+				+	+		+		+	+	+	+		+
r of holes in labial ce	6	5	1	1	1	4	6	4	3	5	1	1	1	1	1	1	7	3	1	1	1	1	1	7	7	6	6	1	1	2	1	1	7	5	1	1	3	6	5	6	1	1	
r of holes ending in												1						1				1					6			1	1												1
oles ending in	6	5	1	1	1	4	6	3	3	4			1	1			5	3	1		1			7	7	5				1		1	7	5	1		3	6	5	6			
es ending in pulp								1		1	1				1	1	2			1			1			1		1	1							1					1	1	
chamber	+		+	+			+	+	+	+	+	+		+	+	+	+		+		+	+		+	+			+			+	+	+	+			+	+	+	+	+	+	1
round base		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+		+	+	+	+			+	+	+	+	+	+	+	+	+	+	+	+	+	
ld disks retained	1	1			1		4	1	2	2	1													7	7								1	2			3	6	5	6			+
round	+	+	+	+	+		+	+	+	+	+													+	+								+	+			+						+
irregular	+						+	+		+	+													+	+									+				+	+	+			2
V-shaped								V								V							V																			V	+

shovel effect Concretions, mostly of the salivary type, are traceable in almost every case More or less severe abrasion of the occlusal surface of the teeth is nearly always present

Numbers 3, 6, 18, 24, and 39 illustrate the various types of designs found These vary from a tooth having a single hole to one with five, six, or seven disks, sometimes arranged in a triangular pattern Numbers 4 and 11 illustrate the two types of plate patterns found One is cut in the shape of a four-leaf clover, the other is simply an irregular thin plate of gold

Plates III and IV illustrate a number of conditions which are found frequently For example, the first tooth on the upper left (No 1), an upper central incisor, shows the characteristic distribution of stain as it occurs in many of these teeth, the labial surface is quite free from stain for perhaps three millimeters from the cemento-enamel junction This condition would indicate that a marked marginal gingivitis had existed previous to the staining of the teeth In this tooth only one of the six holes contains a metal disk, which in this case is semicircular The X-ray of this tooth in Plate II (No 1) indicates that the base of the disk barely rests in the dentine and that the pulp apparently had undergone considerable recession through the formation of the secondary dentine

Number 2 is a canine tooth To judge from the extremely heavy deposits which extend apically below the cemento-enamel junction, considerable recession of the gums must have occurred Both the X-ray and the photograph show the extreme abrasion of the occlusal surface

Number 3 is also an incisor and illustrates a condition that is consistently present, namely, the hole is round and has a round base In this particular case it is a near-pulp exposure (see Pl IV) The distribution of the stain here indicates that a marked marginal gingivitis existed

Number 4 is an upper left canine, the entire labial surface of which is covered by a thin sheet of gold measuring but 0 15 mm in thickness. Upon removal this sheet or plate showed no evidence of cementation, but the under surface was found to be in the form of a short gold tube, broken open at the pulpal end and apparently formed by punching a small gold rod into the plate directly over the hole The split open end of the tube indicates this method of attachment The labial surface was smoothed off and highly polished

Number 8 is an incisor illustrating a condition typical of many The primitive operator drilled through the enamel and dentine and into the pulp The X-ray in Plate IV indicates this condition very clearly The slight flange on the labial side of the disk shows that it had been hammered into the hole This tooth is a striking illustration of decorative *filing* Both the mesial and the distal corners are filed, giving the crown a V-shaped appearance Numbers 16, 23, and 42 show crowns also filed V-shaped

Number 9 is a lateral incisor with a variation in form that is commonly known today as a "peg lateral" The contact points on this tooth are excessively worn, by long hard usage in mastication

Number 11 is an incisor tooth covered by one of the four-leaf patterns of gold plate The plate in this case is much thicker (0 33 mm) than the one on number 4, and was secured by the same method, except that the hole was carried completely through the pulp chamber and ends in the opposite wall (see Pl IV), probably not a painless operation The great size of the pulp indicates early death of the tissue

Number 15 shows another probable example of gingivitis, the stain being high off the cemento-enamel junction The incisor edge is so severely abraded that the wear has opened up two of the decorative holes from the occlusal

Number 16, an incisor with the crown filed V-shaped, has a single large hole which, though seen indistinctly on the X-ray in Plate IV, penetrated the pulp chamber The root apex shows considerable hypercementosis A marked hypercementosis may also be observed on the apices of numbers 23, 29, and 36

Number 18 is an incisor illustrating some apical absorption and hypercementosis. It has three labial holes, which are shallow and hold no gold In this particular example, the pulp chamber had been opened from the lingual surface by a large hole One is inclined to speculate whether the hole might have served to drain an abscess This could have been the case inasmuch as the conditions indicate the presence of infection and the location of the hole contraindicates any decorative purpose

Numbers 5, 8, 11, 16, and 23 in Plate IV are teeth in which the pulp chamber was penetrated by the decorative hole In number 23 the large size of the pulp and the small, little-worn contact points would indicate that the tooth was yet young when lost by infection

Number 24 is a canine showing a very deeply filed labial surface holding seven irregular round gold disks which rest just within the dentine This illustrates ideal conditions for retention

Number 36 is an incisor showing absorption of the root apex, hypercementosis, and a large pulp, conditions indicating infection and an early loss of the tooth

Number 37 is a canine holding a plate attached as previously described The only new condition here is that the plate has been so deeply polished that the outlines of the pins are exposed The location of the contact points in this tooth is such that some irregularity of tooth arrangement is indicated

It should be noted in Plate IV that severe abrasion of the incisal edge is the rule

Spectroscopic analysis [19] of these disks demonstrated the presence of gold, silver, and copper One disk from number 8 and two from number 43 were used in making this analysis The color and a specific gravity of about 15 indicates a preponderance of gold

From such a detailed examination of each specimen it may be concluded that the holes, although varying from 1 to 2 3 mm in diameter, were drilled by some cylindrical instrument with a round end or base, that it was purely by chance that the operator stopped short of the pulp in any instance The great variety in the shape and size of the disks is no doubt accounted for by the fact that they were used more or less as found in nature and were not subjected to any preparation beyond the possible selection of one of approximate size To judge from the flanges on the labial sides of the disk and the absence of anything indicating an auxiliary attachment other than a mechanical one, it may be assumed that the disks were simply hammered into the holes Retention in many cases was made doubly easy because the hole was larger at the base than at the surface The locations of concretions point to a gingival recession in at least 20 per cent of the teeth The distribution of stains indicates a marginal gingivitis in at least 70 per cent Many of the pulps have been exposed during the operation of drilling the holes Furthermore, there is evidence that suppuration existed in a number of instances. The extreme wear of the incisal edges and contact points implies excessive movement, probably associated with the chewing of betel

[19] This analysis was made by Dr John H Manley, of the Department of Physics, University of Michigan

nut and of harsh and gritty food The presence of salivary deposits on all surfaces of the teeth suggests that this chewing was the total extent of any oral hygiene practiced One tooth (number 37) illustrates a malocclusion of the anterior teeth Number 9 shows the presence of a common variation in form Numbers 2, 8, and 22 indicate the presence of pyorrhetic conditions accompanied, in number 2, by severe alveolar absorption Despite the fact that not a single instance of caries was found in this collection, other pathological conditions present indicate that these people lost their decorated teeth early

The evidence presented demonstrates that these inlaid decorative disks were attached by a method which in practice was a partial combination of the modern gold-foil filling and the cast-inlay methods There is nothing to indicate that these disks and plates were for any other purpose than decoration, inasmuch as no disk occurs where it could not be seen, and in the total absence of caries no need for restorative measures could have existed

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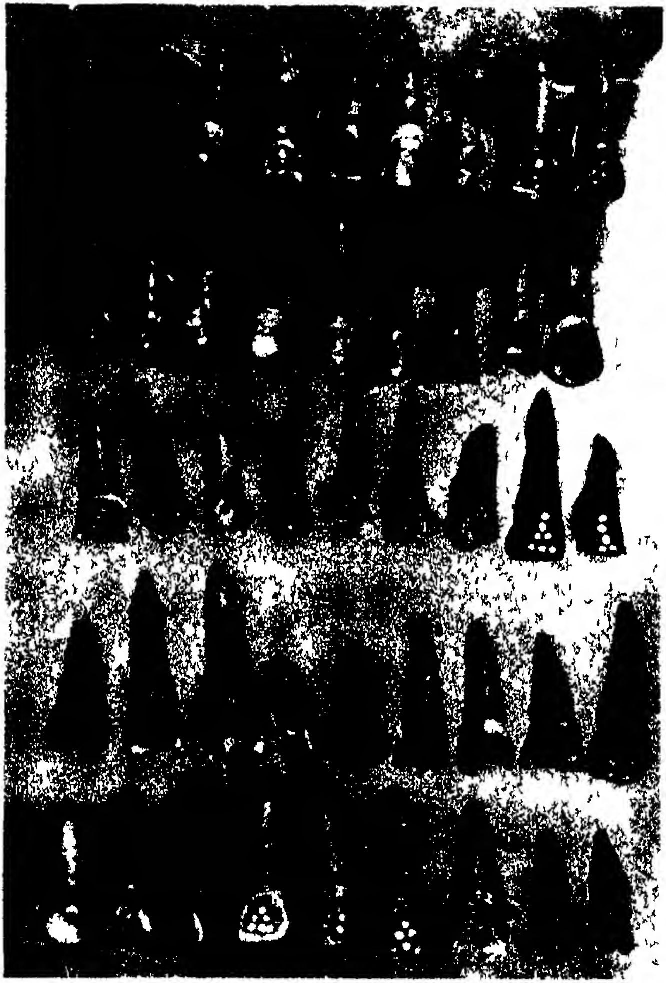
PLATE III



Teeth numbered from left to right: top row 1–7; second row 8–16; third row 17–25; fourth row 26–34; last row 35–43.

PLATE IV

Teeth numbered from left to right top row 1-7 second row 8-16 third row 17-25 fourth row 26-34 last row 35-43

A CHIPPEWA METHOD OF MANUFACTURING WOODEN BROOMS

VOLNEY H. JONES

ALTHOUGH many objects of the material culture of the Indians of the Eastern Woodlands have been satisfactorily described and recorded, others, for no apparent reason, have been largely neglected. One interesting utensil which has had a wide distribution and use, and yet has attracted little attention from ethnologists, is the wooden broom.

As the Homeopathic Hospital Guild Scholar in Michigan Ethnology of the Graduate School of the University of Michigan, I was engaged for a few weeks during the summer of 1933 in a study of the uses of plant materials by the Chippewa Indians of several communities in Michigan and two reservations in Canada. Diligent inquiry revealed that wooden brooms are now made at only one of the communities visited, and there only occasionally. Some individuals in other communities had seen such brooms or knew of them, but the technique of making them had not been known or had been lost.

At the Walpole Island Reservation in Ontario a wooden broom was seen for sale along with splint basketry and other products of local Indian handwork in a store operated by Indians. It had been completed only a short time previously by an Indian who claimed to be over seventy years of age. He stated that this was the only broom which he had made recently, although he had formerly made others on occasion. He refused to undertake another, explaining that the labor involved had proved too strenuous for one of his age. A younger Indian, Levi Sturgeon, was said to be the only other man on the reservation able to demonstrate the method. He was engaged to do so.

Shagbark hickory (*Carya ovata* (Mill.) K. Koch) was the material used, although many kinds of wood were available. Hickory is always employed for this purpose since it is tough, durable, and well

adapted to splitting in the manner desired A smooth young tree was selected and cut A section of the trunk was taken and, after the bark was peeled from it, the base was squared evenly with an axe The log, now ready to be made into a broom, was four feet long, three and one-half inches in diameter at the base, and two and three-fourths at the top

Sturgeon seated himself on a packing box in the shade of a tree and began work The log was held vertically, base upward, between his knees, a knife was used with the right hand, the left remaining free The knife was of a type which has been reported as formerly having been made and used generally by the Indians of the eastern region The curved blade was made of a file worked down to a very sharp edge

The knife blade was inserted under a thin strip of the wood about one-third of an inch wide and about one-sixteenth of an inch thick The loosened end was pulled out a short distance between the knife blade and the thumb After being started with the knife it was grasped with the left hand and stripped free from the log for about fourteen inches The splitting followed the grain of the wood As the strips were peeled down in this manner they were held against the log and out of the way with the knees This process was repeated around the log, which was turned as the work progressed

Plate V gives a series of small models which I prepared to illustrate the various steps in the manufacture of a wooden broom Figure A shows a stick on which work as described above has just begun

After too many strips to be held conveniently between the knees had been pulled down, work was stopped and the strips were beaten against the log with the side of a hammer The peeling of the strips was then resumed and continued until the diameter of the end of the log had been reduced to one and one-half inches All the strips were then beaten into place as before and bound with a piece of hickory bark The broom was then at the stage shown in Plate V, Figure B The end of the log was sawed off with a carpenter's crosscut saw close to the base of the strips, as seen in Plate V, Figure C

After the strips had been released, turned back into their original position, pounded vigorously, and bound into place (Pl V, Fig D), the log was inverted A piece of hickory bark was then tied around it approximately an inch above the base of the strips From this piece of bark a rough measurement of the length of the strips was

taken up the log. About three inches above the section thus measured a mark was made around the log with the knife. Strips were pulled down from the mark to the piece of bark, which acted as a stop (Pl. V, Fig. E).

The process of peeling the strips here was just as described except that the cut was made into the side of the log rather than into the end. After the strips had been peeled to the depth of one inch, the binding was removed from the inner strips. The outer strips were beaten firmly against the inner ones, and a temporary binding was applied to hold all in place (Pl. V, Fig. F). By means of a handaxe and the knife the ends of all the strips were trimmed until they were made even.

The handle was then trimmed to a uniform diameter of one and one-eighth inches. During this operation the broom was held in a foot-operated vice known as a "shaving horse," a contrivance used by white men in colonial times and taken over by the Indians. It is admirably suited to the woodwork of the Chippewa, one may be seen in the yard of almost every house on the Walpole Reservation. A carpenter's drawing knife was used for trimming the handle, after which the handle was smoothed with glass from a broken windowpane.

The broom was next hung in the sun to dry and left for twenty-four hours. In drying the handle split badly. Sturgeon explained that this would not have occurred had the wood been dampened occasionally. After drying the temporary binding was removed and the strips were ripped more finely with the sharpened handle of a file. Permanent bindings of black ash splint were improvised from discarded basket splints and carefully put in place, thus completing the broom. This broom (Museum of Anthropology, University of Michigan, catalog number 13989) is shown in Plate VI, Figure 1. It was much more carefully made than one for Sturgeon's own use would have been. Such operations as smoothing the handle and putting on the binding of ash splints rather than wire or heavy cord would not ordinarily have been done. The entire job — Sturgeon is very adept at woodwork — required about five hours.

According to Sturgeon, the tradition is that such brooms formerly were used in sweeping the dirt floors of the bark houses. Skinner (4, p. 301) reports a similar use of them by the Menomini of Wisconsin. Sturgeon added that in more recent times there had been a ready sale for them to meat dealers when the custom of putting

sawdust on the floors of meat markets was in vogue, but that there is practically no sale for them at present It was observed that the broom made by the old man, although quite reasonably priced, remained unsold throughout the tourist season, while the sale of splint basketry and various knickknacks was fairly rapid These brooms were not seen in use by the Indians, the labor required to make one is great and their coarseness fits them only for rough work, as in the yards Discarded commercial straw brooms were commonly employed by them for such purposes

In the Museum of Anthropology of the University of Michigan there is a broom of this same type (Pl VI, Fig 2), which was collected at the Walpole Reservation in 1904 by M R Harrington It was made in essentially the manner described above, but not so carefully It, also, is of hickory, probably of the same species chosen for the broom here described It shows signs of hard usage Reports are that such brooms were formerly quite common on the Walpole Reservation, but those mentioned above were the only ones I saw in several days spent there

Although it is not the primary purpose to trace here the origin and the distribution of wooden brooms or to describe the manufacture of them elsewhere, it may be of interest to call attention to a few references known to me and to give some unpublished data received in correspondence

Through the kindness of Professor Frank G Speck of the University of Pennsylvania a small wooden brush was procured recently from Harold Tantaquidgeon, a Mohegan Indian living at Mohegan Hill Community, Norwich, Connecticut This brush, which shows only minor differences in technique from that described above, is nine and one-half inches long It was made of a witch-hazel stick one and one-eighth inches in diameter Mr Tantaquidgeon states (correspondence, March 5, 1934) that he and his father are the only members of the Mohegan group who now manufacture brooms and brushes in this manner, and that they seldom do so, since the process is tedious The tool used by them is an ordinary pocket knife Another type of broom, preferred by the Mohegan to the wooden broom, since it is easier to make, is fashioned "by binding twigs of black birch on a handle of suitable length" Such a broom is "very simple to make and is very useful for sweeping around the yard or in the barn"

The references to wooden brooms in the literature known to me are not numerous, and most of them are not very full Each is treated briefly in the following paragraphs

Speck (6, p 189) describes the manufacture of brooms by the Mohegan and Niantic Indians of New England "Brooms and smaller scrubbing brushes were made of birch sticks They varied much in size, according to their intended use In making them, the end of the stick was frayed and strips of the fiber split down, then turned backwards, gathered in a bunch, and bound together with cord"

Beauchamp (1, p 159) thus speaks of the method employed by the New York Indians in 1905 "The splint broom is still made and finds ready sale in Syracuse A triangular piece of ash is taken, long enough for broom and handle, and the broad end is splintered in the usual way, as shown in figure 42 [Figures 42, 43, and 44 of Beauchamp's Plate 9 are here reproduced as Figures A, B, and C, respectively, of Plate VII, Figure 1] When this is done, a groove is cut around the stick, leaving a space between rather longer than the splintered part This portion is also finely splintered from above and turned back, meeting the ends of the first division as in figure 43 The whole is then stitched with bark thread, and the handle is shaved down as in figure 44"

Skinner (4, p 301) describes the manufacture by the Menomini of Wisconsin as follows "A broom of cedar is of a type formerly used to clean out the lodges A thick, cylindrical post about four feet long is taken and, except for about a foot at one end, is trimmed down to make a slender handle The club end is then split into fine slivers These, bent backward and outward, form the brush, which is secured by a tight belt of bark" Plate 82, opposite page 314 of his publication, illustrating a Menomini broom, is reproduced as Plate VII, Figure 2 The similarity between it and the one collected by Harrington at Walpole in 1904 (Pl VI, Fig 2) will be noted It seems very strange that Hoffman (3) in his paper on the Menomini of Wisconsin, published in 1896, although treating material culture rather exhaustively, did not mention wooden brooms, and that Huron Smith (5) in his ethnobotany of these same Indians, published only two years later than the work by Skinner, also has nothing to say of brooms Whether such brooms were in use for only a short time among the Menomini, or whether they were overlooked or ignored by Hoffman and Smith, is a matter of conjecture

Harrington (2) reconstructs the culture of a Shinnecock village site on Long Island by evidence from excavation, history, and living remnants of the tribe Among the articles possessed by these people at the time that the field work was done (1902) and said by the author to be of "native style" are brushes and brooms (p 258) "Serviceable brushes for cleaning pots were made by splitting the end of a white oak stick into small splints and large brooms were made in the same style" His illustration (Fig 19D, opposite p 254) is here reproduced as Plate VII, Figure 3 As may be seen, it is different from the Chippewa broom and from other brooms and brushes discussed above in that the end of the stick is split, but no strips are turned down from above

Professor Speck (correspondence, February 15 and 28, 1934) has listed for me the localities in which he has seen wooden brooms According to him, they were made by the Scatticook near Kent, Connecticut, until 1900 Other peoples by whom he has seen brooms either being made or being used are Cayuga of Grand River Reservation, Ontario, Wamponoag of Cape Cod, Massachusetts (made of witch-hazel), Algonquin of Maniwaki, Quebec, and Munsee of Ontario

In the museum of the Kansas State Teachers College at Pittsburg, Kansas, there is a wooden broom said to have been used in colonial times for mopping the floors of houses According to information received indirectly from Dean G W Trout, head of the Department of History of that college, through correspondence with Miss Lula McPherson (March 6, 1934), this broom was brought from West Virginia to the Northwest Territory by white settlers before 1787 It is in no way associated with Indians

It is surprising that no reference to wooden brooms is to be found in such likely places as the *Jesuit Relations,* Frances Densmore's *Uses of Plants by the Chippewa,* C C Willoughby's *Houses and Gardens of the New England Indians,* and Huron Smith's papers on the ethnobotany of the Ojibwe, Meskwaki, and Forest Pottawatomie

The evidence given above, although admittedly scant, indicates a distribution of wooden brooms among the Algonkian peoples of New England and the Great Lakes region, and among the Iroquoian peoples of New York and Ontario The distribution coincides roughly with that of wood-splint basketry Much more evidence

would doubtless be gained by a survey of specimens which may be in various museums

Although no direct evidence is available to justify such an opinion, the temptation is to attribute the invention of the wooden broom to the Iroquois and to assume its diffusion from them to the Algonkian — which is the history of many traits But it will be noticed that all the ethnological evidence given above has been gathered since 1900 In the early historical works of the eastern region which I examined no mention of wooden brooms was found Beauchamp (1, p 158) offers interesting historical and linguistic evidence to establish the early use of brooms and the practice of sweeping among the Onondaga, Iroquois, and Mohawk The references, however, do not necessarily apply to wooden brooms, and on this same page, although he speaks of the wooden broom as "early," he also mentions a brush broom The only place in which he seems necessarily to mean the wooden broom is that in which he tells of the gathering of "wood for brooms and baskets" by the Moravian Indians on the Susquehanna in 1762 Even that early date would leave ample time for the trait to have been acquired from the white colonists It has also been noted that the broom in the museum at Pittsburg, Kansas, is not associated with Indians These facts bring up the question whether or not the wooden broom may be of European rather than of Indian origin Since most of the writers quoted imply or leave the impression that it is an Indian invention, it is desirable that its origin be determined This, however, awaits archaeological evidence, additional historical and ethnological evidence, or an examination of the material culture of Europe in colonial times There can be no doubt that brooms and sweeping were of pre-Columbian origin in America, as various types, obviously of Indian invention have been reported from many sections of North America It is only the origin of this particular type which is being questioned

It is neither expected nor hoped that this paper has disposed of the subject of wooden brooms, but it has at least raised the question of their origin, distribution, and types This description of the method of manufacture in one community may offer a basis for comparison of their manufacture in others As the art of manufacture of wooden brooms seems rapidly being lost, such studies, if made, must be undertaken soon

University of Michigan

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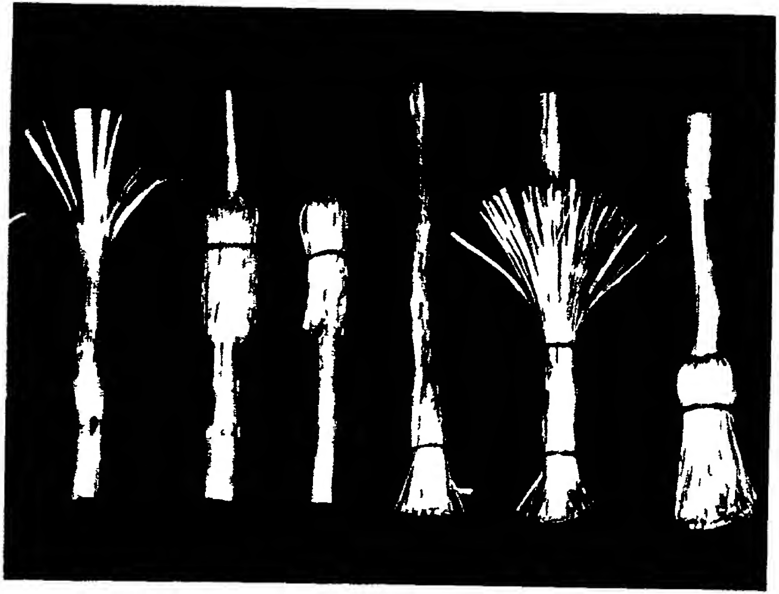
PLATE V



A B C D E I

Models illustrating steps in the manufacture of a broom

PLATE VI

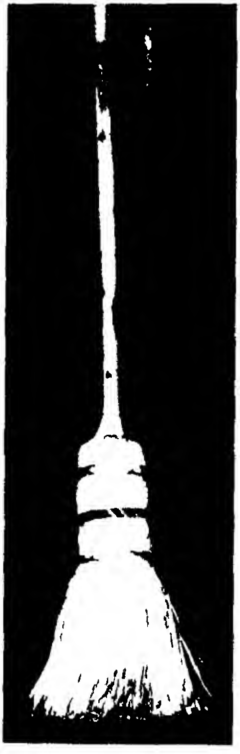
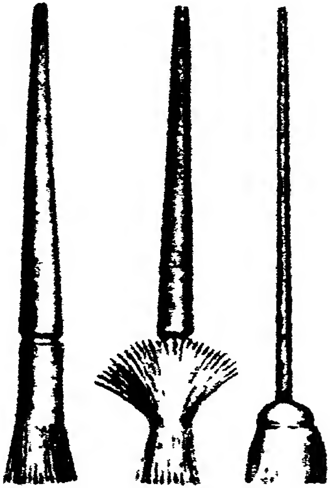


FIG. 1

FIG. 2

FIG. 1. Broom manufactured at Walpole Island Reservation, 1933.
FIG. 2. Broom collected at Walpole Island Reservation, 1904.



A B C

FIG 1

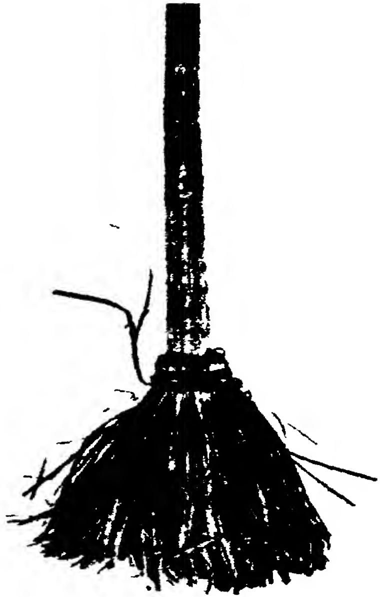


FIG 2

FIG 3

FIG 1 Steps in the manufacture of a broom by New York Indians (courtesy of the New York State Museum, Albany)
FIG 2 Broom manufactured by the Menominee Indians of Wisconsin (courtesy of the Museum of the American Indian, New York)
FIG 3 Wooden brush made by the Shinnecock Indians of Long Island (courtesy of the American Museum of Natural History, New York)

SCLEROSED TYLOSES OF *ELATERIOSPERMUM TAPOS* BL *

ROBFRT A COCKRELL

WHILE the author was making an anatomical study of the wood of *Elateriospermum Tapos* Bl (Euphorbiaceae) a sample was sectioned which was unusual in its thickened tyloses Samples from three trees were examined, two of which contained only a few thin-walled tyloses

Prior to sectioning, the wood was subjected to the usual treatment, namely, boiling in water and immersion in hydrofluoric acid The sections were stained with haematoxylon and mounted in Canada balsam

The sclerosed tyloses were tightly packed in the vessels (see Pl VIII, Figs 1–3) and were conspicuously irregular in size and shape The walls varied in thickness from 10 to 35 microns and possessed a striated structure evident at high magnification and further emphasized by the separation of portions of the tylosis wall along the plane of the striations The walls possessed canal-like ramiform pitting, the pits ranged from less than 1 micron to about 3 microns in diameter, with the larger diameter usually toward the inside of the tylosis The branching systems of pits extended outward from the cavity of the tylosis and connected with pits in the vessel wall or with similar ramiform pits in adjoining tyloses

The layer between contiguous tyloses (middle lamella) took a very dark stain with haematoxylon, the remainder of the wall was only slightly darkened This would seem to indicate a marked similarity to ordinary cell walls, in which the middle lamella likewise takes a deep stain and the secondary wall is only slightly darkened

The sample containing sclerosed tyloses differed from the other two samples in having extremely thick-walled parenchyma cells, but in all other respects the anatomy of the three samples was practically identical

* Contribution No 40 from the School of Forestry and Conservation of the University of Michigan

Sclerosed tyloses similar in abundance to those occurring in *E Tapos* Bl have been reported in *Gymnacranthera paniculata* (A DC) Warb (Myristicaceae) by G A Garratt (*Tropical Woods*, No 35 33 1933) Sporadic sclerosed tyloses have been observed in *Ligustrum glomeratum* Bl (Oleaceae) and in *Artocarpus Forbesii* King (Moraceae)

The sample containing the sclerosed tyloses was obtained from the Yale School of Forestry (Yale No 12660), to which it was supplied by the assistant forest research officer of Kuala Lumpur, Federated Malay States The other two samples were furnished by the New York State College of Forestry from B A Krukoff's first collection of Sumatran woods, Nos 207 and 243

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PLATE VIII

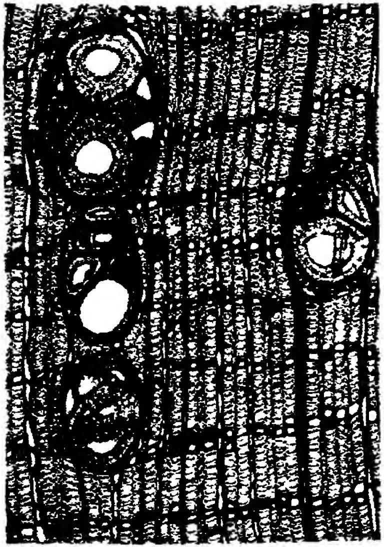

Fig. 1 Transverse section

Fig. 2 Tangential section

Fig. 3 Radial section

ELATERIOSPERMUM TAPOS Bl.

THE WOOD ANATOMY OF THE NORTH SUMATRAN "DJEROEK OETAN," A SUPPOSED NEW GENUS OF RUTACEAE ALLIED TO MURRAYA*

ROBERT A COCKRELL

HERBARIUM specimens and a wood sample of a supposed new genus of the Rutaceae, subfamily Aurantioideae, were obtained by Mr B A Krukoff as part of a botanical collection made in 1932 in Asahan, East Coast of Sumatra Dr E D Merrill, of the New York Botanical Garden, is withholding a technical description and the naming of the tree in honor of the collector until the receipt of more perfect material will enable its affinity to be established with greater certainty Its trifoliolate leaves and large, apparently hard- or firm-shelled fruit distinguish it from other Citrus allies in the North Sumatran flora According to Mr Krukoff, the tree was about forty-five feet high and had a spiny trunk, but the smaller branches were without spines It bore the Malay name "djeroek oetan," which means "forest orange"

General features of wood

Pale yellow (heartwood not evident), slightly lustrous, heavy, very hard, curly-grained, very fine to fine in texture, without distinctive odor or taste

Gross structure

Growth rings plainly visible to the naked eye, numerous (5–16 to a cm), defined at the boundary by fine, pale yellow bands of terminal parenchyma

Vessels barely visible to the naked eye, rather sparse to moderately numerous, solitary or in short radial rows, evenly distributed, very

* Contribution No 41 from the School of Forestry and Conservation of the University of Michigan

small to small, vessel lines quite pronounced, somewhat wavy, slightly darker than the background

Parenchyma terminal (see under "growth rings")

Rays barely visible to the naked eye, lighter-colored than the fibrous tissue, fairly numerous to numerous, fine, ray fleck low, inconspicuous, of the same color as the remaining tissue

Minute anatomy (see Pl IX)

Growth rings plainly delimited by a 1–7-seriate band of terminal parenchyma and by rays which flare slightly where they cross the parenchyma band, cells of terminal parenchyma sometimes flattened in the tangential plane

Vessels solitary, in radial rows of 2–5, and less frequently in nests of 3-5, 6–13 to a square mm, oval to orbicular, the largest reaching 130 microns in diameter, vessel members 200–450 microns in length, bluntly caudate to truncate, walls 3–6 microns in thickness, perforations simple, horizontal to oblique, intervessel pit pairs numerous and crowded, polygonal to orbicular or oval, 3–6 microns in diameter, bordered, with linear-elliptical, horizontally aligned apertures extending to edge of the pit chamber, frequently several apertures horizontally confluent, pit pairs leading to rays and parenchyma abundant, many to each cell, orbicular to oval or less frequently oblong-oval to angled, 3–9 microns in diameter, semibordered, the border usually quite pronounced, tyloses not evident, yellowish brown gum plugs often at the perforations or rarely vessels completely filled with gummy infiltration

Fibers tending to be radially aligned, fine, semilibriform to libriform, angled (cross-section), 12-20 microns in diameter, 400–1300 microns in length, walls 4-6 microns in thickness, interfiber pit pairs abundant, restricted to the radial walls, minute, simple, with short elliptical, steeply inclined apertures, dark gummy infiltration scanty

Parenchyma paratracheal, terminal, and metatracheal, in cambiform rows of 2–5 (mostly 4) cells along the grain, frequently these divided further into 2 to several compartments, each containing a solitary crystal, (*a*) paratracheal parenchyma fairly abundant, occurring as an interrupted uniseriate band about the vessels or frequently as occasional cells contiguous to the vessels, the cells flattened and reaching 40 microns in diameter, (*b*) terminal parenchyma abundant,

forming 1–7-seriate continuous or infrequently interrupted bands which terminate the growth rings, occasionally two of these bands confluent (discontinuous growth rings), (c) metatracheal parenchyma relatively sparse, occurring as isolated cells scattered through the fibrous tissue or occasionally in short tangential bands similar in appearance to terminal parenchyma, cells of terminal and metatracheal parenchyma inserted in the radial rows of fibers and reaching 25 microns in diameter, walls about 2 microns in thickness, infiltration not evident

Rays 6–13 to a mm, homogeneous, 1–3-seriate and up to 45 microns in width, reaching 40 cells and 90 microns in height, composed entirely of procumbent cells, the cells frequently divided into two or more compartments, each containing a solitary crystal, traces of yellowish infiltration usually present, starch deposits not observed

Material — Krukoff's second Sumatran Collection, No 4233, Soengei Masihi, Asahan, East Coast of Sumatra

The wood resembles closely that of many other rutaceous genera, and the similarity to some of them is so great that it was very difficult or even impossible to find a basis for separation This fact is not surprising, for Janssonius (1908), in a study of eleven genera of the Rutaceae, pointed out that "The woods of all the species investigated differ only slightly from one another" The following comparative study of "djeroek oetan" and several rutaceous genera was based on the writer's own anatomical descriptions of *Merrillia caloxylon* (Ridl) Swingle (Krukoff 308) and *Micromelum pubescens* Bl (Krukoff 4359) and the published descriptions of Pearson and Brown for Evodia, Zanthoxylum, Murraya, Limonia, Atalantia, Feronia, Aegle, and Chloroxylon (1932), of Janssonius for Zanthoxylum, Lunasia, Aegle, Glycosmis, Murraya, Micromelum, Acronychia, Clausena, Citrus, Feronia, and Evodia (1908), of Kanehira for Acronychia, Clausena, Evodia, Zanthoxylum, Fagara, and Murraya (1921), and of Lecomte for Murraya, Feronia, and Acronychia (1925) Except for slight differences in texture it was not possible to find any reasonably constant basis for separation of "djeroek oetan" and Micromelum Murraya, Merrillia, Atalantia Aegle, Glycosmis, and *Limonia acidissima* L differ from "djeroek oetan" only in having lower rays (up to 22 cells high) and in lacking crystals in the ray cells, in all other anatomical features they are practically identical *Limonia acidissima* L has been renamed *Feronia limonia* (L) Swingle

and is the only species in the genus In wood anatomy it differs appreciably from two species formerly included in the same genus (*Feronia lucida* Scheff and *F elephantum* Correa), which have recently been removed to the genus Feroniella Lunasia and Acronychia may be distinguished from "djerock oetan" by the fact that their rays are in part heterogeneous Zanthoxylum and Fagara come very close to "djeroek oetan" but paratracheal parenchyma is essentially wanting in both, likewise in Chloroxylon the paratracheal parenchyma is more scanty, and the vessels are more decidedly radially grouped Evodia, Clausena, and Citrus are quite distinct from all the foregoing genera in that they have more abundant paratracheal parenchyma and sometimes do not have the same clearly defined bands of metatracheal parenchyma

In the latest system of classification (Engler, in Engler und Prantl, 1931) most of the genera whose wood structure resembles that of "djeroek octan" are placed in the subfamily Aurantioideae On the basis of wood anatomy "djeroek octan" would seem to belong in this subfamily in the subtribe Hesperethusinae, along with Micromelum, Merrillia, Murraya, and Glycosmis

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PLATE IX

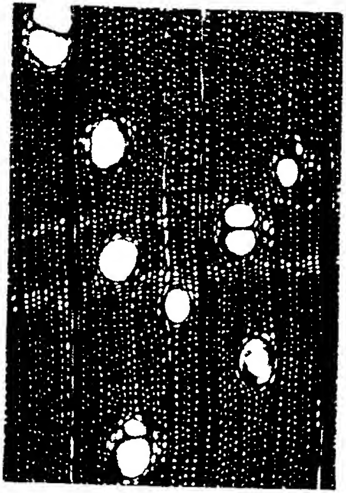

Fig. 1. Transverse section

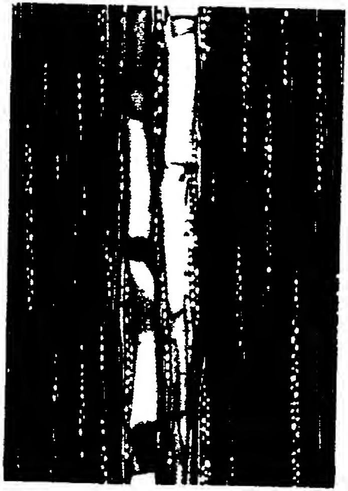

Fig. 2. Tangential section

Fig. 3. Radial section

DJEROEK OETAN OF NORTH SUMATRA

THE DISTRIBUTION OF JUNCUS IN KANSAS *

FREDERICK J. HERMANN

THE flora of Kansas is of more than usual interest because of the situation of the state at the meeting point of the areas covered by our manuals of the western, eastern, and southern floras. Rydberg's and Nelson's manuals cover an area extending east to the western boundary of Kansas, the 1913 edition of Small's manual includes an area extending north to the southern boundary of the state, the seventh edition of Gray's manual includes the eastern third of Kansas. The entire state is covered only by Britton and Brown's manual, the western limit in which coincides with the western boundary of Kansas and the southern limit with the southern boundary, and by Rydberg's *Flora of the Prairies and Plains*. It is to be expected, then, that extensions of range which bring additional species within the area covered by the two northeastern manuals will occur more frequently in Kansas than in most other states.

A study of the Juncus material in the Kansas State Herbarium, which was generously loaned to the writer by Dr. F. C. Gates, has added three species and one variety to the areas included by Gray's *New Manual of Botany* and the *Illustrated Flora* of Britton and Brown. These are the southern *J. validus* Coville, the western *J. balticus* Willd. var. *montanus* Engelm., *J. kansanus*, a hitherto undescribed species most nearly allied to the western *J. brachyphyllus* Wiegand, and the western *J. neo-mexicanus* Wiegand.

The genus as a whole is rather poorly represented in Kansas. In the State Herbarium there are only 15 species as compared, for example, with 22 known from Michigan and 24 from Indiana. If Kansas is compared with coastal states, where the group is naturally more highly developed, its paucity of species is even more marked, for California has 31 and New York 30. It is worthy of note that

* Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 468.

J bufonius L , a species credited with a ubiquitous distribution in North America by all our manuals, is apparently totally absent from Kansas, or at least must be of rare occurrence there The most abundant species, by far, is *J Torreyi* Coville, represented by 62 collections in the State Herbarium Next are *J interior* Wiegand, represented by 38 collections, and *J marginatus* Rostk , represented by 17 collections *J macer* S F Gray, perhaps the most plentiful species throughout the eastern and most of the central states, is represented by only 6 sheets, all from the eastern border of the state

Included in the State Herbarium material were three collections of a critical species belonging to the trilocular series of the section Poiophylli, which it seemed at first might prove to be only a marked geographical variety of *J brachyphyllus* Wiegand, but further study showed it to be also closely related to the eastern (chiefly of the coastal plain) *J Greenei* Oakes & Tuckerm and, also, to possess some affinity with the eastern *J secundus* Beauv , but to differ from all these so consistently in conservative morphological characters that it seems necessary to propose it as a new species, *J kansanus*

KEY TO JUNCUS IN KANSAS

a Inflorescence apparently growing from the side of the culm (the involucral bract terete, erect, and appearing like a continuation of the culm), leaves reduced to bladeless sheaths

  b Stamens 3 opposite the sepals, inflorescence usually ample, greenish or straw-colored, rootstock short-creeping with inconspicuous internodes, culms densely clustered 6 *J effusus* var *solutus*

  b Stamens 6, opposite the sepals and petals, inflorescence sparse, dark brown at maturity, rootstocks long-creeping, with conspicuous internodes, culms usually well separated, arising in a single row 7 *J balticus* var *montanus*

a Inflorescence obviously terminal (or, if not, the involucral bracts flat or channeled along the upper side), leaves with a well-developed blade

  b Leaves flat, or in age involute, not septate

    c Flowers inserted singly on the branches of the inflorescence (not in heads), each with a pair of bracteoles at the base in addition to the bractlet at the base of the pedicel

      d Auricles at the summit of the sheaths very thin, white and scarious, conspicuously produced above the point of insertion (1–3 5 mm long) 1 *J macer*

      d Auricles cartilaginous, yellow, very rigid and glossy, especially the short produced portion, inflorescence generally compact and perianth widely spreading 2 *J Dudleyi*

d Auricles firm, often cartilaginous along the side below the summit, the very slightly produced portion membranaceous, firm but not rigid (easily broken), pale brownish, inflorescence generally loose

e Capsule completely 3-celled — 5 *J kansanus*

e Capsule 1-celled or imperfectly 3-celled, the septa extending about halfway to the center (crescent-shaped after dehiscence)

f Perianth 3–4 mm long, erect or slightly spreading, equaling the capsule — 3 *J interior*

f Perianth 4 5 5 mm long, widely spreading exceeding the capsule — 4 *J neo-mexicanus*

c Flowers in heads not bracteolate (i e with only the bract at the base of the pedicel)

d Stamens exserted in fruit, the ovate, shining capsule usually exceeding the perianth, heads numerous (20–100), few (2–5-) flowered — 15 *J aristulatus*

d Stamens not exserted in fruit, the obovate, dull capsule shorter than the perianth, heads fewer (2–20), many- (5 10-) flowered

e Petals ovate or oblong, blunt — 14 *J marginatus*

e Petals lanceolate, aristate — 14a *J marginatus* var *setosus*

b Leaves terete, hollow provided with septa

c Stamens 3, opposite the sepals

d Capsule tapering evenly to the tip or subulate-beaked, distinctly exceeding the calyx

e Heads numerous, 2–7 flowered, inflorescence very large and diffuse — 11 *J diffusissimus*

e Heads few, densely many flowered

f Capsule with a true beak, the valves in dehiscence united above by the beak, their margins revolute, stamens as long as the perianth — 9 *J scirpoides*

f Capsule without a true beak, tapering evenly to the tip, the valves in dehiscence flat and separating throughout, stamens about one half as long as the perianth — 10 *J* ı

d Capsule obtuse or acute, about equaling or slightly exceeding the calyx

e Heads 1 50, several- to many-flowered, perianth 3–3 5 mm long

f Capsule acute or acuminate — 13 *J acuminatus*

f Capsule obtuse or truncate, abruptly apiculate — 13a *J acuminatus* f *obtusatus*

e Heads 200–500, few-flowered, perianth 2–2 5 mm long — 12 *J nodatus*

c Stamens 6 — 8 *J Torreyi*

SECTION POIOPHYLLI

1 J MACER S F Gray, Nat Arr Brit Pl, 2 164 1821, Fernald, Journ Bot, Dec, 1930

J tenuis of Gray's Manual of Botany, Seventh edition, and most American authors, not Willd

Fields and roadsides, occasionally open woods Chiefly northeastern counties

ATCHISON Co, *A S Hitchcock*, Oct, 1896 LEAVENWORTH Co, *G L Clothier and H N Whitford*, Aug 3, 1897 WYANDOTTE Co, Argentine, *M Reed*, 1891 CHEROKEE Co, Monmouth, *A A Jacobs 59* SHAWNEE Co, Auburn, *P Maus 849* WABAUNSEE Co, Wabaunsee, *P Maus 221*

J bufonius L, a small annual species with the inflorescence more than half of the height of the plant (that of the perennial *J macer* less than one third of the height of the plant), should be looked for along muddy ditches, clay roadsides, and dried ponds throughout the state

2 J DUDLEYI Wiegand, Bull Torr Bot Club, 27 524 1900

Open sandy or sterile soil Generally a calciphile Chiefly in northern half of state

RILEY Co, Manhattan, *W A Kellerman*, Mt Prospect, *F Dale*, *J B Norton 528* (in part) CLOUD Co, *S V Fraser 68* (in part) SALINE Co, south of Iron Mound, *J Hancin 1632* ROOKS Co, Rockport, *E Bartholomew*, June 1, 1890 COMANCHE Co, *A S Hitchcock*, Aug, 1896 TREGO Co, Wa-Keeney, *M Reed*, July 8, 1892 DECATUR Co, *A S Hitchcock*, June 2, 1897 SHERIDAN Co, *A S Hitchcock*, June 21, 1897

3 J INTERIOR Wiegand, Bull Torr Bot Club, 27 516 1900

Prairies and dry woods Chiefly in eastern two thirds of state

LINN Co, *G L Clothier and H N Whitford*, Aug 9, 1897 BOURBON Co, *G L Clothier and H N Whitford*, Aug 11, 1897 CRAWFORD Co, Pittsburg, *P A Rydberg and R Imler 173, 174* (in part) CHEROKEE Co, *A S Hitchcock*, May, 1896 LABETTE Co, *A S Hitchcock*, Aug, 1896 NEOSHO Co, *A S Hitchcock*, Aug, 1896 ALLEN Co, *A S Hitchcock*, Sept, 1896 ANDERSON Co, *A S Hitchcock*, July, 1896 MONTGOMERY Co, road between Caney and Havana, *P A Rydberg and R Imler 450* WILSON Co, Roper, *W H Haller*, June 4, 1895 COFFEY Co, *G L Clothier and H N*

Whitford, Aug 31, 1897 SHAWNEE Co, Topeka, *B B Smyth*, 1886, June, 1891, Aug 8, 1892 JACKSON Co, St Mary's, *J B Norton and G L Clothier*, July 4, 1895 BROWN Co, Fairview, *B Skinner*, June, 1888 NEMAHA Co, *G L Clothier and H N Whitford*, July 27, 1897 MARSHALL Co, *G L Clothier and H N Whitford*, July 25, 1897 RILEY Co, Manhattan, *W A Kellerman*, July, 1886, *J B Norton 528* (in part) MORRIS Co, *J M Westgate*, Aug 10, 1898 CLAY Co, Clay Center, *C Weber 22* DICKINSON Co, *A S Hitchcock*, June, 1896 MARION Co, *J B Norton*, Aug, 1898 BUTLER Co, White Water, *A S Hitchcock*, July, 1892 COWLEY Co, Winfield, *J F Martin*, 1888 SEDGWICK Co, Wichita, *M A Carleton*, May 20, 1892 HARVEY Co, *G L Clothier and H N Whitford*, Aug 24, 1897 McPHERSON Co, McPherson, *T A Waugh*, June 12, 1886 SALINE Co, Saline, *J Hancin 205* LINCOLN Co, *A S Hitchcock*, July, 1895 RENO Co, Turon, *A S Hitchcock*, July, 1892 STAFFORD Co, *A S Hitchcock*, Sept 1, 1897 OSBORNE Co, Covert, *S J Neher 228* RUSH Co, *A S Hitchcock*, Aug, 1895 EDWARDS Co, *O Finch 106* CHEYENNE Co, *A S Hitchcock*, June 28, 1897

4 J NEO-MEXICANUS Wiegand, Bull Torr Bot Club, 30 447 1903 Prairies

SHAWNEE Co, dry soil north of Auburn, *P Maus* (distributed as *J balticus*), July 4, 1927 Previously reported, apparently, only from Arizona and New Mexico

Immature specimens of *J interior*, which have the capsule shorter than the perianth, should not be confused with this species

5 **J kansanus**, sp nov

Caules 2 5–5 5 dm alti, validi, rigidi, erecti, diam 1 3 1 8 mm, teretes vel paulo compressi, alte sulcati, folia caule ½ usque ⅘ breviora, vagina laxa, pallida, marginibus membranaceis, auriculis parvis (0 65 mm longis), firmis membranaceisque, lamina 6–10 cm longa, 0 75–1 3 mm lata, crassissima, plana vel paulo involuta, inflorescentia terminalis, pluriflora, brevis et densiuscula, ramis adscendentibus, bracteae inferiores frondescentes 1–10 cm longae, quam inflorescentia saltem infima longiores, flores conferti, plerumque aliquantulum secundi, vulgo ferrugineo-straminei (aliquando pallide viridi-fusci), sepala petalaque rigida, adscendentia, lanceolato-subulata, marginibus latis scariosis, inaequalia, sepala 4–6 mm, petala 3 5–5 mm longa (plerumque fere 1 mm sepalis breviora),

stamina 6, petalis dimidio breviora, filamentis quam antheris oblongis dimidio brevioribus vel eas fere aequantibus, fructus firmus, petala aequans, ovato-conicus, obtusatus vel truncato-emarginatus, lateribus ad basim convexis, supra planis, trilocularis, semina 0 55–0 6 mm longa, 0 2 mm lata, oblonga, plerumque paulo gibba, brevissime caudata, leviter reticulata — Specimen typicum, conservatum in Herbario Collegii Manhattanensis, legit A S Hitchcock, Concordia, Cloud Co, Kansas, June 17, 1897

Culms 2 5–5 5 dm high, stout, rigid, erect, 1 3–1 8 mm wide, terete to slightly compressed, deeply grooved, leaves one fifth to one half of the length of the culm, sheaths loose and pale with membranaceous margins, their auricles slightly produced (0 65 mm), firm and membranaceous, blades 6 10 cm long, 0 75–1 3 mm wide, very thick and flat or somewhat involute, inflorescence terminal, many-flowered, short and rather compact, the branches ascending, bracts foliaceous, 1–10 cm long, at least one exceeding the inflorescence, flowers crowded, generally somewhat secund, usually deep stramineous (sometimes pale greenish brown), perianth rigid, ascending, the firm, lance-subulate segments with broad scarious margins, unequal, the sepals 4–6 mm, the petals 3 5–5 mm long (usually nearly 1 mm shorter than the sepals), stamens 6, half as long as the petals, the filaments half the length of the oblong anthers or nearly equaling them, capsule firm, equaling the petals, ovateconical, obtuse or truncate-emarginate, completely three-celled, the valves convex near the base, flat above, seeds 0 55–0 6 mm long, 0 2 mm wide, oblong, generally somewhat gibbous, very shortly caudate, finely reticulate

With *J interior* and *J Dudleyi*, apparently on prairies

Cloud Co, Concordia, *A S Hitchcock*, June 17, 1897 (distributed as *J tenuis*, TYPE), without locality, *S V Fraser 68* (in part, most of the collection is *J Dudleyi*, distributed as *J tenuis*) Chautauqua Co, *A S Hitchcock*, Aug 8, 1896 (See note, p 47)

In habit *J kansanus* bears a close resemblance to *J brachyphyllus*, in its capsule, a remarkable similarity to *J Greenei* It differs from *J brachyphyllus* in its ovate-conical, rather than bluntly oblong, capsule, in its short, congested inflorescence, in its membranaceous auricles, which are much less prolonged than are the decidedly scarious auricles of *J brachyphyllus*, and in its narrower leaves (0 75–1 3 mm wide, in *J brachyphyllus*, 1 5–2 mm) In *J brachy-*

phyllus the capsules are generally largely concealed by the broad scarious margins of the appressed petals, whereas the more narrowly margined, merely ascending, petals of *J kansanus* leave the capsules plainly visible From *J secundus* it differs in its larger flowers and fruit (the perianth 5–6 mm, rather than 2 5–3 5 mm long), in its much narrower and firmer capsule valves, in its longer and wider leaves, and in having the bract much longer than the inflorescence From *J Greenei* it differs in having the capsule shorter than the perianth, the perianth segments lanceolate-subulate rather than broadly ovate, the seeds with obsolete longitudinal ribs, and the leaves flat rather than terete

J Vaseyi Engelm and *J confusus* Coville, both species with three-celled capsules, are to be sought in Kansas, the former along the northern border, the latter in the northwestern counties *J Vaseyi* may be known from any others in this subgenus by its very long tailed seeds, capsule longer than the perianth and nearly terete leaves *J confusus* has a strongly retuse capsule and longer leaves less than 1 mm wide

SECTION GENUINI

6 J EFFUSUS L var SOLUTUS Fernald & Wiegand, Rhodora, 12 90 1910

Marshes and moist meadows

CRAWFORD Co, six miles southeast of Pittsburg, *P A Rydberg and R Imler 172* This specimen approaches var *Pylaei* (Laharpe) Fern & Wieg in having a slight tendency toward sulcate culms and in having occasional flowers in which the sepals exceed the perianth and capsule

7 J BALTICUS Willd var MONTANUS Engelm, Trans St Louis Acad Sci, 2 441 1866

Wet plains Chiefly southern counties in western half of state

RENO Co, *A S Hitchcock*, Aug 25, 1897 STAFFORD Co, *A S Hitchcock*, Sept 1, 1897 GRAY Co, *A S Hitchcock*, Sept 1, 1897 SEWARD Co, *M A Carleton*, Oct, 1892 MORTON Co, *A S Hitchcock*, Aug, 1895 CHEYENNE Co, *A S Hitchcock*, June 28, 1897

SECTION SEPTATI

8 J TORREYI Coville, Bull Torr Bot Club, 22 303 1895

Wet, open soil Throughout

WYANDOTTE Co, *K K Mackenzie*, June 27, 1895 JOHNSON Co, *G L Clothier and H N Whitford*, Aug 7, 1897 MIAMI Co, Paola, *A S Hitchcock*, Aug, 1892 LINN Co, between Pleasanton and Prescott, *P A Rydberg and R Imler 116* BOURBON Co, *G L Clothier and H N Whitford*, Aug 11, 1897 LABETTE Co, Labette, *G L Clothier and H N Whitford*, Aug 18, 1897 NEOSHO Co, *A S Hitchcock*, July, 1896 ALLEN Co, *A S Hitchcock*, July, 1896 ANDERSON Co, *A S Hitchcock*, July, 1896 FRANKLIN Co, *A S Hitchcock*, July, 1896 DOUGLAS Co, *Z D F Brown*, Aug 10, 1896 BROWN Co, *G L Clothier and H N Whitford*, July 29, 1897 JACKSON Co, St Mary's, *J B S Norton and G L Clothier*, July 4, 1895 SHAWNEE Co, northeast of Auburn, *P Maus*, July 14, 20, 21, 1927, Topeka, *E A Popenoe*, June 29, 1878 OSAGE Co, *Z D E Brown*, June 5, 1899 COFFEY Co *G L Clothier and H N Whitford*, Aug 31, 1897 WILSON Co, Roper, *W H Haller*, June 4, 1896 MONTGOMERY Co, five miles northeast of Caney, *P A Rydberg and R Imler 425* GREENWOOD Co, Eureka, *A S Hitchcock*, July, 1892 POTTAWATOMIE Co, St George, *G L Clothier*, Aug 3, 1895 NEMAHA Co, *G L Clothier and H N Whitford*, July 7, 1897 RILEY Co, Manhattan, *C H Thompson*, July 26, 1892, Sand Lake, Manhattan, *F C Gates 14076* MORRIS Co, *J M Westgate*, Aug 10, 1898 COWLEY Co, *G L Clothier and H N Whitford*, Aug 22, 1897 SEDGWICK Co, *G L Clothier and H N Whitford*, Aug 24, 1897 SUMNER Co, Wellington, *A S Hitchcock*, July, 1892 MARION Co, *J B Norton*, Aug, 1898 SALINE Co, Saline, *A W Jones*, May 4, 1892, southwest of Falun, *J Hancin 403*, three miles south of Iron Mound, *J Hancin*, June 17, 1931 OTTAWA Co, *A S Hitchcock*, July, 1895 CLAY Co, Clay Center, *C Weber 313, 314* CLOUD Co, *S V Fraser 62* WASHINGTON Co, *G L Clothier and H N Whitford*, July 24, 1897 REPUBLIC Co, Scandia, *D K Thomas*, 1890 JEWEL Co, Webber, *J B S Norton*, Sept 23, 1895 MITCHELL Co, *M A Carleton* KINGMAN Co, *A S Hitchcock*, Aug 23, 1896 HARPER Co, *A S Hitchcock*, Aug 11, 1896 BARBER Co, Medicine Lodge, *A S Hitchcock*, July, 1892 PRATT Co, *A S Hitchcock*, Aug, 1896 OSBORNE Co, Portis, *S J Neher 295* PHILLIPS Co, *H W Baker*, Nov, 1899 KIOWA Co, *A S Hitchcock*, Aug, 1896 COMANCHE Co, *A S Hitchcock*, Aug 17, 1896 FORD Co, Dodge City, *A S Hitchcock*, July, 1892 HODGEMAN Co, *A S Hitchcock*, Aug, 1895 TREGO Co, *A S Hitchcock*, July, 1895 GRAHAM Co, *A S Hitch-*

cock, June 6, 1897 DECATUR Co, Jennings, *B B Smyth 654* SHERIDAN Co, *A S Hitchcock*, June 21, 1897, *C Weber 272* MEADE Co, *A S Hitchcock*, Sept 1, 1897 SEWARD Co, Cimarron River bottom along U S 54, *F C Gates 16248* CHEYENNE Co, *A S Hitchcock*, June 28, 1897

J nodosus L may be looked for along the northern border of the state It is a smaller, more slender plant than *J Torreyi*, differing from it in having the petals equaling or exceeding the sepals (in *J Torreyi* the petals are clearly shorter than the sepals) and in having a shorter perianth (3 4 mm long, in *J Torreyi* 4-5 mm long)

9 J SCIRPOIDES Lam, Encycl Meth Bot, 3 267 1789
Wet, sandy soil

STAFFORD Co, *A S Hitchcock*, Sept 1, 1897

J brachycarpus Engelm, which somewhat resembles this species but has spherical rather than hemispherical heads, sepals exceeding the petals, and the mature capsule only one half to two thirds of the length of the calyx, may occur in the southeastern section of the state

10 J VALIDUS Coville, Bull Torr Bot Club, 22 305 1895
Wet, sandy prairies Southeastern counties

CHAUTAUQUA Co, *A S Hitchcock*, Aug 8, 1896 (distributed as *J scirpoides*)

J polycephalus Michx, similar to this species in inflorescence but with very broad, flat (laterally compressed), and incompletely septate leaves and capsule with a true beak, should be looked for in the southeastern counties

11 J DIFFUSISSIMUS Buckley, Proc Acad Nat Sci Phila, 9 1862
Low grounds Chiefly eastern half of state

CRAWFORD Co, north of Pittsburg, *P A Rydberg and R Imler 140* CHEROKEE Co, *A S Hitchcock 843* MONTGOMERY Co, *G L Clothier and H N Whitford*, Aug 19, 1897, near Caney golf links, *P A Rydberg and R Imler 427* SALINE Co, prairie south of Iron Mound, *J Hancin 316* CLOUD Co, *S V Fraser 66, 67* KINGMAN Co, *A S Hitchcock*, Aug 23, 1896 SHERIDAN Co, *C Weber 385*

12 J NODATUS Coville, Britt & Brown, Ill Fl N U S, 1 482 1913
J robustus Coville, not S Wats
Swamps Eastern half, chiefly southern counties
CHEROKEE Co, *A S Hitchcock 842*, *G L Clothier and H N*

Whitford, Aug 14, 1897 NEOSHO Co, *A S Hitchcock,* Aug, 1896 ANDERSON Co, *A S Hitchcock,* July, 1896 CLOUD Co, *S V Fraser 65*

13 J ACUMINATUS Michx, Fl Bor Am, 1 192 1803
Marshes and low fields
SALINE Co, *J Hancin 1503*

J debilis Gray, a lower plant with 2-7-flowered heads and capsule distinctly exceeding the calyx, and *J canadensis* J Gay, which has definitely tailed seeds and the capsule usually somewhat longer than the calyx, may occur along the eastern border of Kansas

13a J ACUMINATUS Michx, forma **obtusatus,** f nov

A forma typica recedit fructu brevi obtusissimo vel truncato abrupte apiculato et foliis flaccidis Specimen typicum in herbario F J Hermann, June 16, 1933, Repaupo, Gloucester Co, New Jersey, F J Hermann, No 4444

Differs from the typical form in its short, very blunt to truncate, abruptly apiculate capsule and in its flaccid leaves which are very flat when dry

POTTAWATOMIE Co, *J B Norton 529*

SECTION GRAMINIFOLII

14 J MARGINATUS Rostk, Monog Junc, 38, Plate 3, Fig 3 1801
Low, sandy fields Eastern half of state

LINN Co, Pleasanton, *A S Hitchcock,* Aug, 1892 BOURBON Co, *G L Clothier and H N Whitford,* Aug 11, 1897 CRAWFORD Co, *P A Rydberg and R Imler 174* (in part) NEOSHO Co, *A S Hitchcock,* July, 1896 FRANKLIN Co, *A S Hitchcock,* July, 1896 MONTGOMERY Co, *P A Rydberg and H N Whitford 427A* (in part) ELK Co, *G L Clothier and H N Whitford,* Aug 20, 21, 1897 POTTAWATOMIE Co, St George, *J B S and J B Norton and G L Clothier,* July 23, 1895 CLOUD Co, *S V Fraser, 63, 64* SALINE Co, west of Brookville, *J Hancin 457* ELLSWORTH Co, Kanopolis, *M Becker,* 1896 KINGMAN Co, *M A Carleton,* Sept, 1891

14a J MARGINATUS Rostk var SETOSUS Coville, Proc Biol Soc Wash, 8 124 1893
J setosus (Coville) Small

KINGMAN Co., *M. A. Carleton*, Oct., 1892.

In Kansas, where this variety probably reaches the northern limit of its range, there are found all intermediate stages between it and the typical species. *J. setosus* (Coville) Small cannot, therefore, be accorded more than the varietal rank originally assigned to it.

15. J. ARISTULATUS Michx., Fl. Bor. Am., 1: 192. 1803.

Moist meadows. Eastern half of state, chiefly southern counties.

LINN Co., Pleasanton, *A. S. Hitchcock*, Aug., 1892. CRAWFORD Co., six miles south of Pittsburg, *P. A. Rydberg and R. Imler 174* (in part). MONTGOMERY Co., *P. A. Rydberg and R. Imler 427A* (in part). ELK Co., *G. L. Clothier and H. N. Whitford*, Aug. 20, 1897. SALINE Co., west of Kipp and southwest of Iron Mound, *J. Hancin 961*.

UNIVERSITY OF MICHIGAN

SUPPLEMENTARY NOTE

When this paper went to press the only known stations for *J. kansanus* were those cited above, all in Kansas. A specimen from Missouri has recently been located, however, in the University of Michigan Herbarium. This was collected by Rev. John Davis (No. 8824), June 25, 1917, on dry, rocky slopes at Eolia, Pike County, and distributed as *J. interior*. The collection is a mixture containing a few culms of *J. interior*, but it is largely *J. kansanus*.

POLLEN STATISTICS FOR TWO BOGS IN SOUTHWESTERN MICHIGAN

PAUL K HOUDEK

LOCATION OF THE BOGS

THE two bogs under consideration are but twenty-five miles apart in the southwestern corner of the Southern Peninsula of Michigan One of them, the Stevensville Bog, is about three and one-half miles southwest of the village of Stevensville, Berrien County, Michigan, and one-fourth mile west of United States Highway No 12 It occupies a small circular depression approximately one hundred yards in diameter in the southwest corner of the Grand Marais lake region which lies between the sand dunes and the supposed former shore of Lake Michigan This dune bog is well advanced, having a tiny bit of open water surrounded by the usual stages of plant succession The surface vegetation is typical of similar areas in this region, and since many accurate lists are available, notably one by Fuller (3), the species are not here enumerated

Hall Lake Bog is four miles east of the village of Hartford, Van Buren County, Michigan It lies just south of United States Highway No 12, at the west end of Hall Lake The mat extends entirely across the west end of the lake about a hundred yards from the west edge of the depression The lake proper is roughly oval, being three tenths of a mile in its greatest diameter It lies in a glacial depression and is slowly being filled by the bog The mat is well formed, and, although apparently grounded, it is very wet The surface of this bog is not so mature as that of the Stevensville Bog

METHODS

Collecting — Samples of the deposited materials were collected at half-meter depth intervals by means of a Hiller peat borer Those for microscopic examination were very carefully removed from the centers of the cores and placed in glass tubes Two or three samples were taken from different positions along each core Larger ones

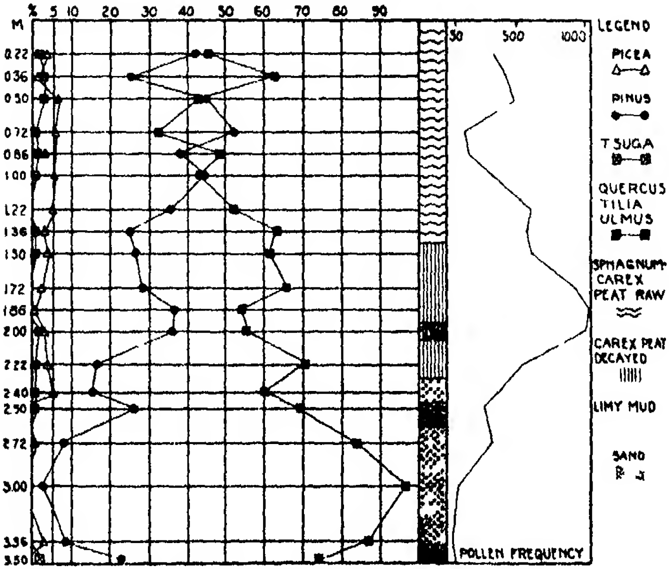

FIG 1 Pollen diagram, Stevensville bog

for gross examination were taken from each core and placed in tight paper boxes

Preparations — The peat was prepared for microscopic examination in accordance with the method described by Voss (6) A small quantity was boiled in ten per cent solution of potassium hydroxide, then twice decanted, washed, and centrifuged Some of the peat was then mounted in glycerine jelly under large cover glasses J E Potzger, in a paper read before the botany section of the Indiana State Academy of Science, Indianapolis, December 5, 1931, objected to the use of potassium hydroxide on the basis that it would distort the pollen grains No demonstration or other evidence of the amount or the character of the distortion was offered It is reasonable to expect some distortion, but until a better method of loosening the pollen grains from the other materials in the peat has been discovered, the method given seems to be the most practicable As pollen grains are known to be everywhere present in dusts, constant care was

TABLE I

PERCENTAGES OF THE SIGNIFICANT TREE POLLENS STEVENSVILLE BOG

Depth in m	Abies	Picea	Pinus	Tsuga	Acer	Carpinus	Betula	Ostrya	Fagus	Fraxinus	Juglans	Liquidambar	Quercus	Tilia	Ulmus	Quercus Tilia, and Ulmus
0.22	0.6	3.8	42.0	1.9	1.2	0.6	1.2		2.5		0.6		43.4	0.6	1.2	45.2
0.36		2.0	25.3	2.6		0.6	2.0	0.6	0.6	2.0	0.6		58.7	1.3	2.6	62.6
0.50	1.3	5.8	45.2	2.6	0.6					0.6	1.3		40.6		1.9	42.5
0.72	1.9	5.2	52.3	0.6	3.2	0.6	1.4				1.3		30.5	0.6	1.3	32.4
0.86	2.0	2.6	38.0	1.3		0.6	3.3		2.6		0.6		42.5	0.6	5.3	48.4
1.00	0.6	5.0	44.3	0.6	0.6	0.5			4.3		0.6		36.7	0.6	5.7	43.0
1.22		4.5	35.6		2.0		0.5	0.5	4.0				44.5	2.5	5.0	52.0
1.36	1.0	3.1	25.2	0.5	0.5		3.1		0.5	2.0	0.5		60.2		3.1	63.3
1.50	0.5	3.5	26.7	0.5	0.5	1.0	0.5		4.0	0.5	1.0		56.3	3.0	2.0	61.3
1.72	0.6	1.9	28.3			0.6			1.9			0.6	63.8	0.6	1.3	65.7
1.86	1.6	0.5	36.7		0.5	0.5	1.6	0.5	2.6		1.0	0.5	51.4	0.5	2.1	54.0
2.00	0.6	2.4	36.0	1.2			1.2		3.6				52.7	0.6	1.8	55.1
2.22	2.2	3.8	16.5	0.5	1.1		1.1		3.8				68.6	1.1	1.1	70.8
2.40	9.4	5.0	15.6	0.6		0.6	3.7	0.6	3.1		0.6		55.0	1.2	4.3	60.5
2.50			28.6	0.5			1.6		1.6	1.1			66.5	1.1	1.6	69.2
2.72	0.6	0.6	8.3		0.6	0.6	1.9	0.6	3.1				78.0	1.2	4.4	83.6
3.00	0.6		3.0										92.0	0.6	3.7	96.3
3.36		1.9	8.6		1.3	0.6	0.6						82.0	1.9	2.6	86.5
3.50	0.6		23.0	1.9	0.6								71.5	0.6	1.3	73.4

taken to avoid contamination For gross examination the peat was boiled in ten per cent potassium hydroxide solution, filtered, washed, and spread out in a large shallow glass dish Illumination from below aided in sorting out the plant parts

Examination and identification — The pollen grains were identified by comparing them with modern pollens Through the courtesy of the Field Museum of Natural History of Chicago a collection of pollens was made from preserved specimens in their herbarium Hundreds of grains were examined and measured to determine the sizes and size ranges for some of the types that are difficult to identify Sear's work on pollen (4) was extremely helpful in the identification One hundred and fifty to two hundred and ten pollen grains were counted for each sample Peat types were determined by comparisons with type samples named by Dr G Erdtman, of the University of Stockholm, and by examination of the peat for plant remains other than pollen grains

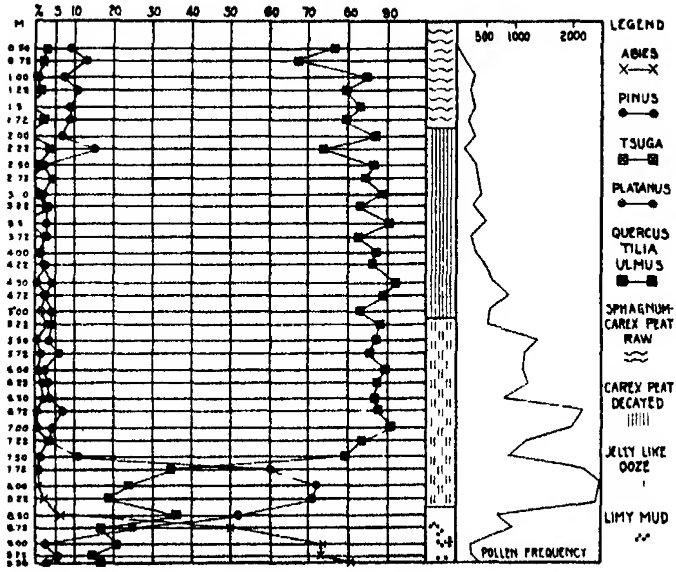

Fig 2 Pollen diagram, Hall Lake bog

Obviously diagrams could not be used to represent all the pollen grains found Only the more significant ones have thus been represented in the tables of results which follow Salix, Larix, Corylus, and Alnus are so general in their distribution that, in accordance with a suggestion from Dr Erdtman, their pollens were omitted from the calculations Pollen frequency is the calculated number of pollen grains to be found on one square centimeter of the slide of that sample

RESULTS

The results of the investigation are presented in the pollen diagrams (Figs 1–2) and the tabulated pollen percentages (Tables I–II)

SIGNIFICANCE

Pollen percentages — According to Auer (1), " The pollen content of the successive layers of the individual peat bogs is a direct indication of the comparative abundance of the different kinds of trees

TABLE II

PERCENTAGES OF THE SIGNIFICANT TREE POLLENS, HALL LAKE BOG

Depth in m.	Abies	Picea	Pinus	Tsuga	Acer	Betula	Carya	Celtis	Carpinus	Ostrya	Fagus	Fraxinus	Juglans	Liquidambar	Platanus	Quercus	Tilia	Ulmus	Quercus Tilia, and Ulmus
0.50	1.2	0.6	9.3	3.1	0.6	2.5	1.8				1.2	1.8	0.6			67.5	0.6	8.7	78.8
0.72	0.6	2.6	12.7	2.0	0.6	1.3	0.6		1.3		5.3	5.3				58.0	1.3	8.0	67.3
1.00			7.3	0.6		2.6					1.3	1.3	1.3			81.2	0.6	3.3	85.1
1.22	0.6	1.3	10.4	1.3	0.6	0.6	1.9			0.6	1.3	0.6	0.6			74.6	0.6	4.5	79.7
1.50	1.0	1.3	9.2			0.6			1.9	1.3	0.6					79.0		3.9	82.9
1.72		1.3	9.2	1.9		4.6				0.6	0.6	1.3	0.6			76.[illegible]	1.0	1.3	79.4
2.00		1.8	6.7			0.6			0.6		1.2	1.8				81.7		5.4	87.1
2.22	0.6	2.0	15.3	3.3		2.0					1.3		1.3			67.2	2.6	4.0	73.8
2.50	1.2		2.4	0.6	0.6	3.1	1.1	1.2	0.6			0.6	0.6			79.5		6.8	86.3
2.72	1.1	1.1	4.5		0.5	0.5	0.5				2.2	2.2	1.7	0.5		75.5	2.2	6.8	84.5
3.00	0.6	1.3	1.9	1.3		0.6					2.6	3.2				70.7	3.2	14.3	88
3.22	0.6		3.2	3.[illegible]		1.9					2.6	3.9	1.3			74.5	0.6	7.8	82.9
3.50	0.6	0.6	3.1			0.6	0.6			0.6	1.[illegible]	1.3	0.6			79.0	0.6	10.7	90.3
3.72	0.6	0.6	3.1	1.8		1.2	1.8		0.6			5.0			2.5	68.0	2.5	11.9	82.4
4.00	0.6	0.6	1.2	0.6		0.6				0.6	4.5	1.[illegible]	1.[illegible]		1	82.5		4.5	87.0
4.22			2.5			1.2			0.6	0.6	3.2	2.5	1		1.9	76.8	1.[illegible]	7.7	85.7
4.50	0.6		0.6			0.6						1.3			4.6	80.0		12.0	92.0
4.72	0.5	0.5	2.3	0.5		1.7					1.7	0.5	0.5		2.3	8[illegible]	0.5	6.3	89.0
5.00		2.6	4.2							1.0	1	3.1	1.[illegible]	0.6	1.5	80.0		3.1	83.1
5.22	0.5		4.3						0.5		1.0	1.6		0.6	3.2	76.5	1.6	9.8	87.9
5.50	0.4	0.4	3.6			0.9					3.6	1.3	1.8		0.4	78.0	0.4	8.6	87.0
5.72	0.9		5.0		0.4	0.9					2.9	0.9	0.4		1.4	79.7	0.9	4.9	85.5
6.00	0.5		2.7	0.5	1.6						3.2	1.0			1.0	82.2		7.0	89.[illegible]
6.22	1.0	0.5	3.5								2.5	2.5	0.5		[illegible].0	79.3		8.0	87.3
6.50	0.6		3.6		0.6	0.6				0.6	4.2	0.6		0.6	2.4	75.0	0.6	10.8	86.4
6.72	0.5	0.5	6.8								2.8	0.5	0.5		0.5	7[illegible].8	1.1	13.6	87.5
7.00			4.9			0.6			0.6		1.8	0.6	0.6		0.6	78.2		1[illegible].2	90.4
7.22	3.6	0.5	4.1			0.5			0.5		2.0	1.0	0.5		4.1	73.5	0.5	[illegible]	83.2
7.50	1.3	1.3	11.2		1.3	1.3				0.6	1.3	0.6	0.6		1.3	68.5		10.5	79.0
7.72	0.5	0.5	60.0		0.5	0.5					1.1	0.5	0.5		1.1	20.9	0.[illegible]	3.9	34.3
8.00	0.5		72.5			1.6					1.0	0.5				17.9		5.9	[illegible]3.8
8.22	2.0	1.5	71.0			5.1			0.5		1.0					13.[illegible]		5.6	18.8
8.50	6.1		52.8			3.3					1.6					30.9		5.0	35.9
8.72	50.2	2.5	25.7			4.5										14.8		1.9	16.7
9.00	73.5		2.5		0.6	1.8					0.6					18.[illegible]		2.5	20.7
9.22	73.0	3.0	5.4			0.6			1		1.8		0.6			12.7		1.8	14.5
9.36	80.3		2.6			0.6										15.6		1.3	16.9

growing as the peat layers formed" If this statement is true, this investigation shows changes in the tree floras of the regions in which the deposits occur. The older deposits in the Stevensville Bog contain a predominance of Quercus-Ulmus pollens. The later ones show a reduction of the Quercus-Ulmus with an increase of Pinus pollens. In the Hall Lake Bog the oldest deposits contain a decided predominance of Abies pollen. This diminishes rapidly in favor of the Pinus pollens. In the next younger deposits the Quercus-Ulmus

pollens predominate, continuing to the surface In the more recent deposits there is a slight reduction in the Quercus-Ulmus and a gain in Pinus pollens The greater antiquity of the bottom layers of the Hall Lake Bog is quite evident from the predominance of Abies pollen This is typical of the majority of bogs in this region that have been investigated by Auer (1), Sears (5), and Voss (6) It is very likely that deposition of material began considerably later in the Stevensville Bog than in the Hall Lake Bog Further work is needed before conclusions can be drawn These studies may lead to a comparative statement regarding the age of the dunes In the later deposits there is considerable variation in the several pollen percentages of the two bogs This would seem to indicate that the immediate vicinity of the bog has some influence on the pollen content of the deposited material It also indicates that perhaps safer conclusions can be drawn from the study of a number of bogs in a given region than from the investigation of a single deposit

The primary conclusions of most of the investigations in this field have concerned climatic changes inferred from changes in the flora as indicated by the pollen grains found at the different levels Doubtless many of these conclusions are well founded Some of the pollen percentage changes shown in the results of this investigation would be interpreted by certain workers as indicating climatic changes A report on but two bogs is, perhaps, not the place for such interpretations

Peat types — The peat types indicate the character of the surface at the time of deposition The mud at the bottom of Hall Lake Bog is similar to that found in the bottoms of new lakes It is composed of material washed in from the surrounding terrain, some marl, and a small amount of completely decayed vegetable material The jelly-like ooze shown in Figure 2 is regarded by Davis (2) as having been deposited under a Carex mat The author found such material under open water in front of a Carex mat in Mud Lake Bog near Douglas Lake, in the northern part of the Southern Peninsula The other peat types above the jelly-like ooze contain sufficient plant remains to make their origin quite obvious In the Hall Lake Bog they are similar to those found by Voss (6) in the Antioch Bog and by the author in a northern Michigan bog now under investigation There is little doubt but that they represent the different methods of filling of which a record is found in the glacial depressions of

this region The peat types of the Stevensville Bog are individually identical with some of the types in the Hall Lake Bog, but the entire section indicates a development quite different in character and, perhaps, in rate As indicated in Figure 1, the deposits at the two and the two and one-half meter depths in the Stevensville Bog are almost pure sand This might have been water-born, but it was probably blown in at the time of the formation or the shifting of the neighboring sand dunes

Pollen frequency —If a uniform procedure is followed in the preparation of the slides, the pollen counts will indicate the relative amount of pollen grains in the different types of peat or other deposited materials There seem to be four factors that affect the amount of pollen grains in a peat sample first, the amount of pollen that falls on the area, second, the ability of the surface to receive the pollen, third, the preservative qualities of the material which receives the pollen, and, fourth, the resistance of the pollen grains to decomposition In the two bogs investigated there seems to be a distinct correlation between the peat types and the pollen frequency This is best illustrated between the five and twenty-two hundredths and the eight and twenty-two hundredths meter depths of the Hall Lake Bog Here we find changes in the pollen frequencies at the same depths as the changes in the peat types It is interesting to note that at the same levels there are few, if any, changes in the pollen percentages

SUMMARY

1 The two bogs investigated exhibit striking differences

2 Deposition of material probably began considerably later in the dune bog (i e the Stevensville Bog) than in the glacial depression

3 The Hall Lake Bog gave results that are similar to those secured by other workers on other bogs in this region

4 The Hall Lake Bog indicates a forest succession in that region of Abies, Pinus, and Quercus-Ulmus

5 Correlation of bog studies such as these may throw light on the problem of the age of the dunes

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NEW OEDOGONIA COLLECTED IN CHINA II*

CHIN-CHIH JAO[1]

IN THE preceding volume of the *Papers* (19 83 92) the writer began a series of articles on Chinese Oedogonia, of which this is the second His sister, Miss Tu Jao, has continued to make collections that yield interesting new species, and others have come to hand from other sources The numerous new species recently described by the writer from a locality so much frequented by botanists as Woods Hole, Massachusetts, indicates that the publication of Hirn's great monograph by no means left Oedogonium a worked-out group It is therefore not to be wondered at that China continues to be productive of novelties

Oedogonium brevicingulatum, sp nov

(Tab X, Figg 1 3)

Oedogonium monoicum, oogoniis singulis, paululum tumidis, oboviformi-globosis vel oboviformibus, poro superiore apertis, oosporis globosis, longitudinaliter oogonia non complentibus, membrana laevi et frequenter crassa, antheridiis 1- vel 4-cellulis, subepigynis, subhypogynis, vel sparsis, plerumque cum cellulis vegetativis alternantibus, spermatozoidiis binis, divisione horizontali natis, cellula terminali apiculata, cellula basali brevi, interdum leviter tumida

Cellulae vegetativae	(22) 25–32 μ diam , 48–125 0 μ long
Oogonia	38 51 μ diam 48 58 0 μ long
Oosporia	35 45 μ diam , 38–45 0 μ long
Cellulae antheridii	25–29 μ diam , 3–6 5 μ long

Monoecious, oögonium solitary, a little tumid, obovoid-globose to obovoid, pore superior, oöspore globose, not filling the oögonium longitudinally, spore wall smooth and often thick, antheridia 1–4, subepigynous, subhypogynous, or scattered, mostly alternating with

* Papers from the Department of Botany of the University of Michigan, No 465

[1] Fellow of the China Foundation for the Promotion of Education and Culture.

the vegetative cell, sperms 2, division horizontal, terminal cell apiculate, basal cell short, sometimes slightly swollen

Vegetative cells	(22) 25–32 μ diam, 48–125 0 μ long
Oögonia	38–51 μ diam, 48–58 0 μ long
Oospores	35–45 μ diam, 38–45 0 μ long
Antheridia	25–29 μ diam, 3–6 5 μ long

This species has the appearance of *Oe geniculatum* Hirn It differs, however, in the smaller dimensions of all cells and in that the oospores are regularly globose It also has some characteristics of the groups of *Oe capilliforme* Kützing & Wittrock and *Oe princeps* (Hassall) Wittrock, both of which, however, are dioecious

Collected in rice farm near Lu-Tian-Tse, about nine miles west from Chungking City, Szechwan, West China, by Miss Fu Jao, June, 1933 Filaments abundantly scattered in *Hydrodictyon reticulatum* (L) Lagerheim, *Oedogonium Kurzii* Zeller, *Oe crassum* (Hassall) Wittrock, *Oe spiralidens* Jao, *Spirogyra intorta* Jao inedit, and some blue-green algae Types in C C Jao collection and in Herb Mich Univ, Nos S497 and S504

Oedogonium peipingense, sp nov

(Tab X, Figg 4–8)

Oedogonium dioicum, macrandrium, oogoniis singulis, oboviformibus, operculo apertis, circumscissione superiore, angusta, oosporis globosis, rarissime subglobosis, oogonia non complentibus, membrana laevi, antheridiis 2- vel 5 (vel ?)-cellulis, saepe cum cellulis vegetativis alternantibus, spermatozoidiis binis, divisione horizontali natis, cellula basali aut tumida aut non tumida, cellula terminali apice obtusa vel setiformi longitudine usque ad 310–378 μ

Cell veg, planta fem	16–29 μ diam, 55–160 μ long
Cell veg, planta masc	16–26 μ diam, 55–122 μ long
Oogonia	61–68 μ diam, 71–96 μ long
Oosporia	51–61 μ diam, 51–66 μ long
Cellulae antheridii	17–23 μ diam, 13–23 μ long
Cellulae basales	19–32 μ diam, 96–103 μ long

Dioecious, macrandrous, oögonium solitary, obovoid, operculate, division superior, narrow, oöspore globose, very rarely subglobose, not filling the oögonium, spore wall smooth, antheridia 2–5 (-?), often alternating with the vegetative cell, sperms 2, division horizontal, basal cell tumid or not, terminal cell apically obtuse or piliferous and reaching a length of from 310 μ to 370 μ

Vegetative cells, female plant	16–29 μ diam, 5? 160 μ long
Vegetative cells male plant	16–26 μ diam 55–122 μ long
Oögonia	61 68 μ diam, 71–96 μ long
Oöspores	51–61 μ diam 51 66 μ long
Antheridia	17–23 μ diam, 13 23 μ long
Basal cells	19 32 μ diam 96–103 μ long

In this genus the largest known species which is characterized by the macrandrous habit, operculate oogonium, and smooth oöspore is *Oe dioicum* Carter N Carter's description is so imperfect that it leaves doubtful the number and the vertical division of the sperms, and is quite insufficient and vague with regard to all the measurements This species was found in India by Carter only and nobody has described it again The new species, *Oe peipingense,* is near the Indian form, but with only Carter's description, aside from which no data are available, it is very hard to compare the two plants In some respects the appearance of this new species is similar to that of *Oe Welwitschii* West & West, *Oe iowense* Tiffany, and *Oe Pringsheimii* Cramer & Wittrock, but it differs from them chiefly in having larger dimensions and a solitary oogonium, and in sometimes having the terminal cell elongating into a piliferous tip

Collected in the southwest moat of Peiping, by the writer, June, 1928 Filaments scattered, accompanying *Oe cryptoporum* Wittrock, *Oe crispum* (Hassall) Wittrock, *Vaucheria sessilis* (Vauch) De Candolle, *Spirogyra austriaca* Czurda, *S pratensis* Transeau, *S rhizopoda* Jao inedit , and several filamentous blue green algae Types in C C Jao collection and in Herb Mich Univ , Nos H242 S1 and 01

Oedogonium inframediale, sp nov

(Tab XI, Figg 9–10)

Oedogonium dioicum, nannandrium, gynandrosporum, oogoniis singulis, subglobosis, globosis, vel aliquantum subobovjformi-globosis, poro infra medium apertis, oosporis globosis vel subglobosis, oogonia vix complentibus, episporio echinato, echinis ad 6 5 μ longis, androsporangiis 1–5-cellulis, epigynis vel dispersis, nannandribus paululum curvatis, stipitatis, in cellulis suffultoriis sedentibus, antheridiis solitariis, exterioribus, spermatozoidiis binis

Cellulae vegetativae	13 21 μ diam 41–90 μ long
Oogonia	38–48 μ diam, 38–45 μ long
Oosporae	37–44 μ diam, 35–41 μ long
cellulae suffultoriae	16 26 μ diam 54–61 μ long

Androsporangia	13–16 μ diam, 6–16 μ long
Nannandris stipes	8 10 μ diam, 22 24 μ long
Cellulae antheridii	6–7 μ diam, 8–12 μ long

Dioecious, nannandrous, gynandrosporous, oogonium solitary, subglobose, globose, or somewhat subobovoid-globose, pore inframedian, oospore globose or subglobose, nearly filling the oogonium, outer spore wall echinate, spines up to 6 5 μ in length, androsporangia 1–5, subepigynous or scattered, dwarf male slightly curved, on the suffultory cell, antheridium 1, exterior, sperms 2

Vegetative cells	13–21 μ diam, 41–90 μ long
Oogonia	38–48 μ diam, 38–45 μ long
Oöspores	37–44 μ diam, 35–41 μ long
Suffultory cells	16 26 μ diam, 54–61 μ long
Androsporangia	13–16 μ diam, 6–16 μ long
Male stipes	8 10 μ diam 22 24 μ long
Antheridia	6–7 μ diam, 8–12 μ long

This species is characterized by the inframedian pore, the smaller vegetative cells, and the diameters of the oögonia and oospores, which are generally greater than their lengths, in contradistinction to *Oe hystrix* Wittrock

Collected in a pond near Shih-Chiao-Ch'ang, about ten miles westward from Chungking, Szechwan, West China Filaments scattered among many other filamentous algae Types in C C Jao collection and in Herb Univ Mich, Nos S615 01 and 02

Oedogonium oblongum Wittrock var **fusiforme**, var nov

(Tab XI, Figg 11–13)

Oedogonium monoicum, oogoniis singulis, ellipsoideis, valde medio inflatis et utrinque angustatis, operculo supremo apertis, maturitate frequenter deciduis, oosporis ellipsoideis, raro subellipsoideis, oogonia non vel fere complentibus, membrana laevi, antheridiis frequenter 1, interdum 2 3, subepigynis vel subhypogynis, raro dispersis, spermatozoidiis binis, divisione horizontali natis, cellula basali subtiliter tumida, plerumque cellulis vegetativis inferioribus aequilonga, cellulis superioribus vegetativis plerumque brevioribus quam inferioribus, cellula terminali obtusa

Cellulae vegetativae	3 5–7 5 μ diam, 25–58 μ long
Oogonia	22 0–29 0 μ diam, 48 55 μ long
Oosporae	13 0–19 0 μ diam, 22–32 μ long
Cellulae antheridii	3 5–8 0 μ diam, 6–10 μ long
Cellulae basales	6 5–9 5 μ diam, 41–55 μ long

Monoecious, oögonium solitary, ellipsoid, much inflated toward the middle and narrow at both ends, operculate, division supreme, often deciduous at maturity, oospore ellipsoid, rarely subellipsoid, not or nearly filling the oogonium, spore wall smooth, antheridia usually solitary, sometimes 2 3, subepigynous or subhypogynous, rarely scattered, sperms two, division horizontal, basal cell slightly swollen, usually as long as the lower vegetative cells, upper vegetative cells usually rather shorter than the lower ones, terminal cell obtuse

Vegetative cells	3 5 7 5 μ diam ,	25 58 μ long
Oogonia	22 0–29 0 μ diam ,	48 5[illegible] μ long
Oöspores	13 0–19 0 μ diam	22-32 μ long
Antheridia	3 5–8 0 μ diam	6–10 μ long
Basal cells	6 5 9 6 μ diam ,	41-55 μ long

This variety distinctly differs from its type in having more slender vegetative cells and in rather larger oogonia containing smaller oospores *Oe oblongum* Wittrock f *majus* (Nordstedt) Hirn and f *sphaericum* (Hallas) Hirn both have larger vegetative cells, oöspores, and antheridia, whereas the oospores of the second form are globose, and so these are quite readily distinguished from this new variety In some respects the new variety resembles *Oe oblongellum* Kirchner and *Oe gracillium* Wittrock & Lundell, but it is distinguished from the first by its slender vegetative cells, longer and median swollen ellipsoid oogonia, narrower oöspores not filling the oögonia, and subepigynous, subhypogynous, or sometimes scattered antheridia, and from the second by rather longer vegetative cells and by larger ellipsoid oögonia much inflated toward the middle and narrow at both ends

Collected in a rice farm at Liu-Chia-Tan, about one and one-half miles westward from Kiangpei City and in a pond near Shih-Chiao-Ch'ang, about ten miles westward from Chungking, Szechwan, West China, Dec , 1933 Filaments attached to the rotten leaves of water grasses and mixed with many other filamentous algae Types in C C Jao collection and in Herb Univ Mich , Nos 8549 and 8615

Oedogonium Pringsheimii Cramer & Wittrock var **brevius**, var nov

(Tab XI, Figg 14–15)

Oedogonium dioicum, macrandrium, oogoniis 1 3, depresso-globosis vel suboboviformi-globosis, operculo apertis, circumscis-

sione superiore, oosporis forma oogoniis similibus et ea complentibus, membrana laevi, cellulis suffultoriis plus minusve tumidis, antheridiis 2–6-cellulis, saepe cum cellulis vegetativis alternantibus, spermatozoidiis binis, divisione horizontali natis, filamentis aliquantum abbreviatis, inferioribus cellulis vegetativis gracilioribus et longioribus quam superioribus, cellula basali subtiliter tumida et elongata, cellula terminali late obtusa vel apiculata

Cell veg, planta fem	13–22 μ diam 19–48 μ long
Cell veg, planta masc	10–19 μ diam, 12–51 μ long
Oogonia	29–37 μ diam, 26–38 μ long
Oosporae	26–34 μ diam, 24–35 μ long
Cell suffultoriae	16–26 μ diam, 19–32 μ long
Cell antheridii	10–16 μ diam, 6–10 μ long
Cell basales	16–20 μ diam, 57–64 μ long

Dioecious, macrandrous, oogonia 1–3, depressed-globose or subobovoid-globose, operculate, division superior, oospore of the same form as the oögonium and filling it, spore wall smooth, suffultory cell more or less enlarged, antheridia 2–6, often alternating with vegetative cells, sperms 2, produced by horizontal division, filament somewhat short, lower vegetative cells generally narrower and longer than upper ones, basal cell slightly tumid and elongate, terminal cell broadly obtuse or apiculate

Veg cells, female plant	13–22 μ diam, 19–48 μ long
Veg cells, male plant	10–19 μ diam, 12–51 μ long
Oögonia	29–37 μ diam, 26–38 μ long
Oöspores	26–34 μ diam, 24–35 μ long
Suffultory cells	16–26 μ diam, 19–32 μ long
Antheridia	10–16 μ diam, 6–10 μ long
Basal cells	16–20 μ diam, 57–64 μ long

This variety is characterized by its broader and shorter vegetative cells, smaller fruiting cells, and tumid suffultory cells, in these points it is different from its type and var *Nordstedtii* Wittrock It differs, however, from var *abbreviatum* Hirn in having all cells with greater dimensions and suffultory cells tumid

Collected in a stream near Shih-Chiao-Ch'ang, about ten miles westward from Chungking, Szechwan, West China, Dec 25, 1933 Filaments scattered among other filamentous algae attached to the decaying leaves of water grasses Types in C C Jao collection and in Herb Univ Mich, Nos S608 01 and 02

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PLATE XI

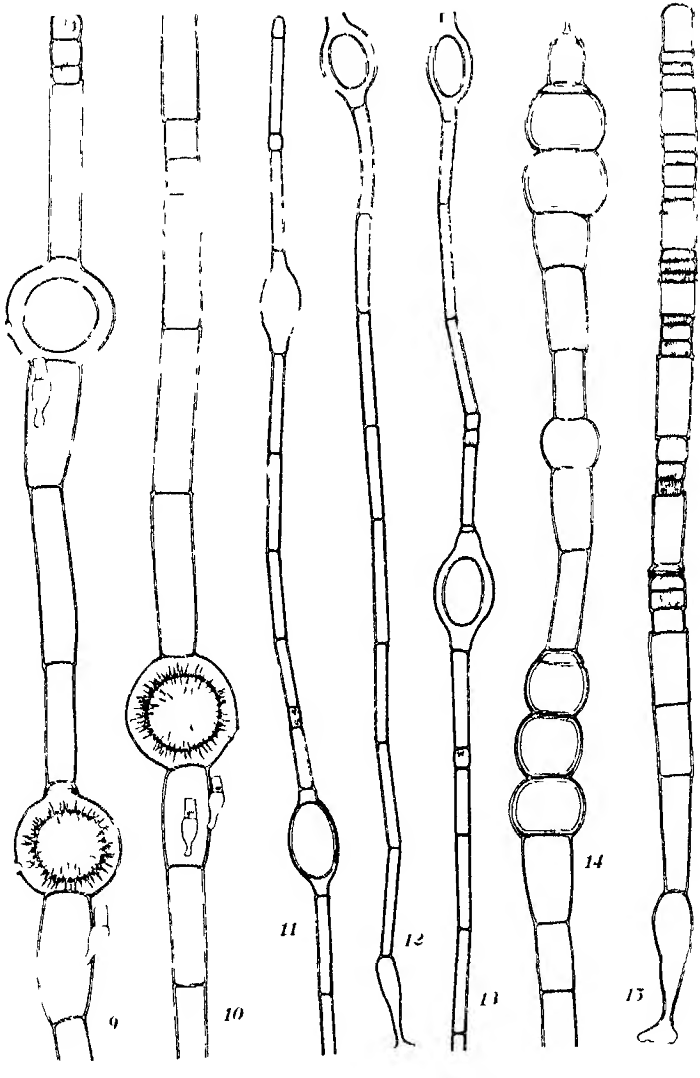
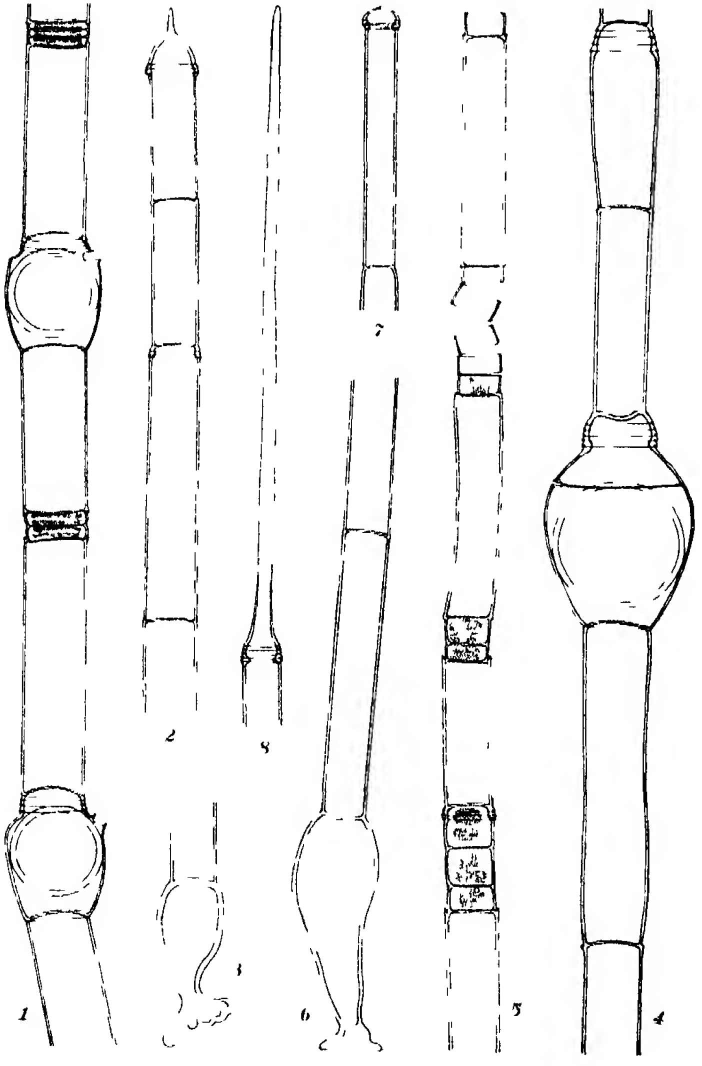


PLATE X



EXPLANATION OF PLATES

PLATE X

FIGS 1–3 *Oedogonium brevicingulatum* sp nov (× 360) Figure 1 a part of the filament with two oogonia and two series of subepigynous antheridia containing the horizontally divided very narrow sperms, Figure 2 an upper part of the filament, showing the apiculate terminal cell, Figure 3, basal cell

FIGS 4–8 *Oedogonium peipingense* sp nov (× 360) Figure 4 a part of the filament, with a mature oogonium, Figure 5 a part of the filament showing the antheridial series alternating with the vegetative cells, Figure 6, basal cell, Figure 7, an apically obtuse terminal cell, Figure 8 a piliferous terminal cell

PLATE XI

FIGS 9–10 *Oedogonium inframediale* sp nov (× 360) Figure 9 a part of the filament, showing both mature (lower) and immature (upper) oogonia and three subepigynous androsporangia Figure 10 a mature oögonium and two scattered androsporangia

FIGS 11–13 *Oedogonium oblongum* Wittrock var *fusiforme*, var nov (× 360) Figure 11, an upper part of the filament showing both mature (lower) and immature (upper) oögonia and two subepigynous and one terminal antheridia, Figure 12 a lower part of the filament showing the basal cell and a fully mature oögonium, Figure 13, a part of the filament showing two oögonia and two series of antheridia in position of subepigynous and sub hypogynous

FIGS 14 15 *Oedogonium Pringsheimii* Cramer & Wittrock var *brevius*, var nov (× 360) Figure 14, an upper part of the filament showing three series of oögonia and an apiculate terminal cell, Figure 15 a male plant showing the antheridial series alternating with the vegetative cells, the basal cell, and the broadly obtuse terminal cell

NOTES ON NEW OR UNUSUAL MICHIGAN DISCOMYCETES II *

BESSIE B KANOUSE

OF THE twenty-six species of Discomycetes discussed in this paper, twenty are newly recorded from Michigan, so far as can be determined from available records The list includes one new genus, three new species, and one new variety *Phaeohelotium flavum*, gen nov et sp nov , *Phialea Cassandrae*, sp nov , *Calloria Solidaginis*, sp nov , and *Lachnella tricolor* (Sow) Phill var *microspora*, var nov All collections cited have been determined by the author and are preserved in the Herbarium of the University of Michigan

Thirty-two of the forty-two collections cited were made in the month of May, for the greater part by E B Mains, A H Smith, and the author Grateful acknowledgment is given to Dr Mains for the photographs

STICTIDACEAE

NAEMACYCLUS NIVEUS (Pers) Sacc (Pl XV, Fig 3) — Found in abundance on the fallen needles of *Pinus sylvestris* L , Ann Arbor, May 12, 1933, Smith (33 1151), May 19, 1933, Saginaw Forest, University of Michigan, Ann Arbor, Smith and Mains (M [1] 33-10) Nannfeldt (11) discusses the taxonomic position of the genus in connection with the Ostropaceae and says "Es ist mir zur Zeit nicht moglich die systematische Stellung dieser Art anzugeben obwar es anzunehmen ist, dass sie Propolis nahestehe " Rehm included it in the Stictidaceae

TRYBLIDIACEAE

CALOSIA SABINA (De Not) Rehm (Pl XIV, Figs 3 4) — Pinckney, May 13, 1933, Mains (33-27) and May 17, 1933, Mains, Smith,

* Papers from the Department of Botany and the Herbarium of the University of Michigan No 471

[1] The letters M and S used with the collection numbers refer to the collectors, E B Mains and A H Smith, respectively

and Kanouse (M 33-674) Von Hohnel (7) transferred this species to Eutryblidiella in the family Tryblidiaceae, as *E sabina* (De Not) v H The plants were thickly scattered on dead branches of living bushes of *Juniperus communis* L The characteristic spores are illustrated in Plate XIV, Figure 3

DERMATEACEAE

Calloria Solidaginis, sp nov [2] (Pl XII, Fig 2) — Apothecia sessile, arising under the rind, breaking through or pushing it up, gregarious, solitary or caespitose, frequently crowded in groups of from two to many, often appearing in lines, not opening to a disk, remaining cup-shaped, drying inrolled, 0 5–1 mm in diameter, hypothecium thick, soft, subgelatinous, parenchymatous, exciple well developed, consisting of hexagonal cells with thick, brown-colored walls, margin bordered with long, blunt cells which are paler, parallel, and not extending beyond the margin, hymenium dirty white with violet tints to light brown when fresh, drying darker with rose-lilac shades, outside concolorous to darker, lightly streaked with brown, asci clavate-cylindrical, 4-spored, 45 65 × 6–8 μ, the ascus pore is colored slightly blue with iodine, spores oblong to subfusoid, straight or slightly bent, hyaline, 2-celled with an oil drop in each end, 10–12 × 3–4 μ, paraphyses filiform, scarcely thickened at the apices, a few branched below, hyaline, exceeding the asci but not forming a compact epithecium

On wet mats of dead stems of *Solidago sp* , bank of Huron River, near Dexter, Michigan, May 19, 1933 Type collected by Mains, Smith, and Kanouse (M 33–41), also on *Solidago sp* , Ann Arbor, May 2, 1933, Smith (33–1155)

Conidia were found in some apothecia They are hyaline, subglobose, measuring 5 × 4 μ, with an apiculus at one end The conidia undoubtedly belong to this species since the apothecia bearing them were found always in close association with other

[2] **Calloria Solidaginis**, sp nov , apotheciis sessilibus, caespitosis, erumpentibus demum superficialibus, subgelatinosis, ascis cylindrico-clavatis, 45–65 × 6–8 μ, 4-sporis, apices iodo coeruleo-tinctis, sporis oblongis vel subfusoideis, rectis vel curvatis, hyalinis, uniseptatis, 10–12 × 3–4 μ, paraphysibus filiformibus Specimen typicum a Kanouse Mains, et Smith lectum prope Dexter, Michigan, in caulibus specierum Solidaginis ad ripas fluminis Huron In Herb Univ Mich conservatum est sub numero 33–41

apothecia containing mature asci and ascospores In fact, young asci sometimes were among the conidiophores The apothecia containing conidia were very soft, cushion-shaped disks and had thin, almost separable exciples Rehm (15) reported finding a conidial stage for *Calloria fusarioides* (Berk) Fr

Calloria Solidaginis possesses characteristics which place it within an exceedingly perplexing group A review of the literature on species commonly found on the Compositae confirms this Rehm (15) described *Pezizella fuscohyalina* and placed *Helotium fuscohyalina* Rehm in synonymy He said "Einer Mollisia scheinbar, aber den Gehäusen ganz verscheiden Von der ebenfalls auf Solidago in Frankreich gefunden *Pez umbrinella* Desm (10 Not pag 36 Synon *Niptera umbrinella* (Sacc) Syll Disc pag 48) unterscheidt sie sich insobesonders durch nur einzellige nicht 12–14 μ lange Sporen und kleinere Apothecien" Later (16) he described *Calloria subalpina* Rehm var *discrepans* Rehm on overwintered stems of *Aster leucanthemum* Still later (18) he described *Ombrophila fuscohyalina* Rehm on *Solidago virgaurea* and placed in synonymy with it his own *Pezizella fuscohyalina* and *Calloria subalpina* var *discrepans* and also *Pyrenopeziza fuscohyalina* Boud Concerning *Calloria subalpina* Rehm var *discrepans* Rehm he says "Nahert sich mehr Ombrophila, von *Calloria subalpina* durch die Form der Sporen und J— verscheiden" In the same paper he placed *Calloria subalpina* Rehm in synonymy with *Corynella discrepans* Rehm and appended the remark "Kann wegen der Form der sehr gallertigen Apothecium nicht bei Calloria untergebracht werden" This species is reported by him as occurring on decaying stems of *Aster Tradescanti*

Von Höhnel (6), after having examined material, summarized the situation and cleared up part of the confusion in regard to Rehm's interpretations He discussed *Peziza umbrinella* Desm , *Niptera umbrinella* (Desm) Sacc , *Calloria subalpina* Rehm, *Calloria subalpina* Rehm var *discrepans* Rehm, and *Corynella discrepans* Rehm In conclusion he established a new genus, Calloriella, used the specific name *C umbrinella* (Desm) v H , and reduced to synonymy the species just mentioned

The important characters of *Calloriella umbrinella* are as follows apothecia formed superficially, the negative reaction with iodine,

8-spored asci, and paraphyses with thickened apices The genus is placed in the Dermateaceae by Von Hohnel He regards Didymocoryne Sacc, Calloria Boud emend Rehm (non Fries emend Fuck), and Cenangina v H as closely related genera

In contrast to Calloriella Von Hohnel characterized the genus Calloria as follows apothecia erumpent, subgelatinous, parenchymatous structures with well-developed exciple, 8-spored asci, positive iodine reaction, and paraphyses somewhat branched

Calloria Solidaginis agrees with this generic diagnosis in every respect except the number of spores in the asci In *C Solidaginis* the asci are 4-spored instead of 8-spored Four-spored asci are found in some species of Pyrenopeziza However, the spores are 1-celled and the apothecia are not gelatinous — two characters which prevent *C Solidaginis* being placed in the genus Pyrenopeziza *Pyrenopeziza Artemisiae* (Lasch) Rehm var *Solidaginis* Rehm (Ascomycetes Exsiccati No 1957) is a quite different plant The two photographs (Pl XII, Figs 1 2 of *C Solidaginis* and *P Artemisiae* (Lasch) Rehm var *Solidaginis* Rehm) show clearly the macroscopic differences between the two species

Calloria Solidaginis cannot be referred to the genus Ombrophila, which has stalked gelatinous apothecia, or to Corynella, which has 4-celled spores and colored paraphyses, or to Coryne, which has gelatinous apothecia and many-celled spores, or to Calloriella, for the reasons explained above

Cenangiaceae

Stamnaria americana Massee & Morgan — On overwintered sterile plants of *Equisetum arvense* L, Huron River, Dexter, May 19, 1933, Mains and Kanouse (M 33–670) Apparently this is the spring form of the fungus that we have found occasionally in the late fall and winter on the sporophytes of *E arvense* Von Hohnel (5), in a discussion of *Peziza laetissima* Cesati, cited various European collections that have gone under that name and also under the name *Phragmonaevia laetissima* (Cesati) Rehm He considered them to be merely the spring form of *Stamnaria Equiseti* (Hoff) Rehm, which is the species of Stamnaria common in Europe He found that the apothecia formed in the spring usually contained immature spores In contrast, our collections of *S americana*, made in May, have fully developed spores

exactly like those of collections made in November and December, which were reported in a previous paper by the author (9) The apothecia on the sterile plants seem to be softer than those that develop on the fertile plants In this respect they correspond to the description of the species given by Morgan (10) He described the apothecia as thin and delicate He did not give the season of the year in which his Ohio collections were made

MOLLISIACEAE

BELONIDIUM FUSCOPALLIDUM Bres On wood of *Acer sp*, Saline, June 30, 1933, Smith (33 1152) The apothecia in this collection have the characteristic olive-green color of the species and hyphae which project beyond the margin of the apothecia The asci measure 70 80 × 10 12 μ The spores are hyaline and 3-septate and measure 18 21 × 4 6 μ Rehm (17) questions the placing of this fungus in Belonidium, and suggests that it belongs to Podobelonium as defined by Boudier

TAPESIA FUSCA (Pers) Fuck (Pl XIII, Fig 1) — On dead sticks of *Vaccinium corymbosum* L, Mud Lake Bog, Whitmore Lake, May 28, 1933, Smith, E I Towe, and J B McFarland (S 33 1157), same location, May 23, 1933, Mains (33–50) It was frequently seen on other decayed woods throughout the spring Elliot (4) has pointed out that the development of the fungus varies according to the environment As she states, the blue color seems to be associated with young apothecia growing in humid conditions Although the color of the mature apothecia by which the fungus is commonly known is yellowish, the blue-colored apothecia frequently contain what appear to be mature spores This difference in color may cause trouble in identification In a humid environment, such as the floor of a bog the tomentum remains on the cups for a long time and the subiculum is a well-developed, conspicuous, brown mat

TAPESIA LIVIDOFUSCA (Fr) Rehm var FALLAX (Desm) Rehm (Pl XIII, Fig 2) — On cones of *Picea mariana* (Mill) BSP, Mud Lake Bog, Whitmore Lake, May 28, 1933, Smith (33 106) This fungus was reported by Rehm (17) as growing in Europe on cones of fir and *Pinus sylvestris* The apothecia are seated on a rather scanty but evident brown subiculum The spores measure 6–9 × 2 5–3 μ

Pyrenopeziza Artemisiae (Lasch) Rehm var Solidaginis Rehm (Pl XII, Fig 1) — On decayed stem of a composite, bank of Huron River, Dexter, May 19, 1933, Mains and Kanouse (M 33–38) This fungus is identical with a Canadian collection, No 1957 of Rehm's Ascomycetes Exsiccati, and with No 3866 of Ellis and Everhart's Fungi Columbiani The apothecia are nearly black within and without and have white margins The outside is streaked with patches of dark-colored excipular cells The asci contain either four or eight spores, which are 1-celled, hyaline, and measure 9–10 (12) × 2–3 μ In *P Solidaginis* (Karst) Schröt the spores measure 20 × 2 μ, according to Nannfeldt (11)

Perrotia flammae (A & S) Boud — On wood of *Quercus sp* , Dexter, May 20, 1933, Smith (33–1154) The species is not rare, but this is apparently the first collection from the state

Beloniella brevipila (Rob) Rehm — On overwintered stems of *Aster sp* , Saginaw Forest, University of Michigan, Ann Arbor, May 31, 1933, Mains (33–65) The plants agree with those described by Rehm (15) From the external characters and from the non-septate condition of the immature spores they might be mistaken quite easily for a species of Pyrenopeziza The spores are finally many-septate and reach a length of 27–32 μ Rehm cites one collection on the stem of a composite

Helotiaceae

Pezizella aspidiicola (B & Br) Rehm (Pl XII, Fig 4) — On petioles of *Adiantum pedatum* L , Cascade Glen, Ann Arbor, May 27, 1933, Mains and Smith (M 33–62) The apothecia are very short stalked, sparingly hairy or floccose outside, and bordered at the margin with bundles of hyphae, forming a delicate white fringe The spores measure 6–8 × 1 5–2 μ

Gorgoniceps delicatula (Fuck) v H (Pl XV, Fig 1) — Von Höhnel (8), in a discussion of *Arachnopeziza delicatula* Fuck , has rightly stated that this species does not belong to Arachnopeziza since the spores are filiform and many-septate It seems to be well placed in Gorgoniceps, where Von Höhnel put it It has been reported previously from Michigan under the old name Plate XV illustrates plants collected near Pinckney by Smith, May 17, 1933 (33–1155)

PHIALEA ACICULARUM (Rolland) Rehm (Pl XII, Fig 3) — On fallen, overwintered leaves of *Larix laricina* (Du Roi) Koch, George Reserve, University of Michigan, Pinckney, May 13 and 17, 1933, Mains (33-16), Mud Lake Bog, Whitmore Lake, May 23, 1933, Mains and Smith (M 33-52) Seymour (23) does not list this species as occurring on Larix in North America

Phialea Cassandrae, sp nov [3] — Apothecia solitary, stipitate, cup-shaped, then expanded, pure white, smooth, thin, 0 5 mm wide, stalk 1 5–2 0 mm high, stiff, white above, black below, subbulbous, floccose at base with large, protruding, thin-walled cells, asci cylindrical, 30–35 × 5–6 μ, 8-spored, ascus pore colored faintly blue with iodine, spores fusoid-clavate, pointed at one end, hyaline, 1-celled, 6–8 × 1–1 5 μ, paraphyses filiform, hyaline

On fallen leaves of *Chamaedaphne calyculata* (L) Moench Type collected by Mains (33–59), Mud Lake Bog, Whitmore Lake, Michigan, May 23, 1933, also from the same bog, May 28, 1933, Smith, Lowe, and McFarland (S 33 109), Rock River, June 17, 1933, Smith (33–551)

This beautiful little fungus is distinguished by the small spores and by the contrasting black and white of the stipe Boudier (1) illustrates *Helotium nubilipes* Boud with a white disk and a stipe that is slightly darkened The spores of his plant are 22–23 × 5–6 μ, which is decidedly larger than those in *P Cassandrae*

Schweinitz (21) depicted growing on wood a plant which is labeled in his handwriting as *P nigripes* It has a slender black and white stipe and a white apothecium No adequate description of this species has been found *Helotium nigripes* Fr as characterized by Saccardo (19) has a flesh-colored apothecium A variety of *H nigripes* is merely mentioned by Saccardo as var *alba* By inference it appears that a Cuban collection made by C Wright (No 634, Berkeley & Curtis, Fungi Cubenses, No 702) may be this variety, but neither the species nor the

[3] **Phialea Cassandrae,** sp nov , apotheciis primum cupulatis, deinde applanatis, niveis, glabris, stipitatis, gracilibus, rigidis, 1 5–2 0 mm altis, inferiore parte nigrescentibus, ad basin bulbosis tomento floccoso subtili praeditis, ascis cylindricis 30–35 × 5–6 μ, 8-sporis, sporis fusoideo-clavatis, hyalinis, nonseptatis, 6–8 × 1–1.5 μ paraphysibus filiformibus Specimen typicum legit E B Mains in foliis delapsis Chamaedaphnae calyculatae prope Whitmore Lake, Michigan. In Herb Univ Mich conservatum est sub numero 33–59

variety, both of which grew on wood, seems to be the same as the fungus growing on the leaves of Chamaedaphne

CYATHICULA MARCHANTIAE (Sommerf) Sacc (Pl XIV, Fig 2) — On undetermined liverwort, Point aux Barques, May 30, 1933, J E Davidson and C A Arnold, on *Marchantia polymorpha* L, Mud Lake Bog, Whitmore Lake, July 4, 1933, Mains and Smith (M 33-671) To judge from the account of this species given by Durand (3), these seem to be rather unusual finds Durand says concerning his own collection No 8513, made in 1910, that, if what he had was Sommerfeldt's plant, "we have the interesting fact of the occurrence in New York of a species which has not been found before since its original discovery in Northern Europe more than 60 years ago" Our Michigan collections are additional records for North America

CYATHICULA CORONATA (Bull) De Not (Pl XIV, Fig 1) — This species has been reported previously from Michigan, but it is desired to call attention to the accompanying plate, in which the teeth on the margins of the apothecia are distinctly seen This collection was made near Pinckney, Oct 5, 1933, by E Nissen and Smith (S 33-1159)

LACHNELLA CORTICALIS (Pers) Fr — On *Salix sp*, Saginaw Forest, University of Michigan, Ann Arbor, May 10, 1933, Smith (33-19), Isle Royale, A H Povah,[4] 1930 This species is beautifully illustrated by Boudier (1) Schweinitz (21) has a sketch of an American collection, labeled *P corticola*, which is typical The fungus is readily recognized by the delicate weft of richly branching hairs that envelop the apothecia, giving them soft, fluffy halos Large crystals form at the ends of the hairs Rehm (15) described the margins of the apothecium as much inrolled, so that only a small opening is left, and our plants show this feature nicely The measurements of the asci (50–70 × 7–8 μ) and of the spores (12–14(16) × 3–4 μ) of our plants are slightly smaller than those given by European authors, but are not sufficiently different to be significant Morgan (10) reports finding the species in Ohio

LACHNELLA LEUCOPHAEA (Pers) Boud — On overwintered stems of Arctium, Ann Arbor, May 6, 1933, Smith (33-23). This fungus is cited in literature under several names Phillips (12) gave it

[4] See Povah (14)

the rank of a variety of *Lachnella sulphurea* (Pers) Phill , Rehm (15) called it *Lachnum leucophaea* (Pers) Karst The rough, colored, septate hairs, the unusually large, lance-shaped paraphyses, and the variable spore size are good characters by which it may be recognized

LACHNELLA TRICOLOR (Sow) Phill var **microspora,** var nov [5] — In a discussion of the species *Lachnella tricolor* (Sow) Phill , Phillips (12) says "This is a rare species, easily recognized by its blue-gray exterior " The specific name, *tricolor*, refers to the blue-gray exterior, yellowish hymenium, and nearly white stem Our specimens have these colors and agree in all other respects, with the exception of the size of the spores The spores of the Michigan specimens are much smaller They measure only 5 5 5 × 1 1 5 μ, whereas the measurements given for *L tricolor* are 13-15 × 2 μ Morgan (10) reports from Ohio a species which is said to be "readily distinguished by the green color of every part contracted when dry and looking like minute yellowish-green specks of fluff " The spores of these plants measure 7–9 × 2 μ Massee and Morgan described their plant under the name *Lachnum viridulum* The tricolor of our fungus relates it to the English plants rather than to the American collections with the all-green apothecia As they appear in the field on decaying wood, the apothecia so closely resemble Penicillium that it is quite possible that the ascomycete has been mistaken for the imperfect

On wood of *Quercus sp* Type collected at Cascade Glen, Ann Arbor, Michigan, May 10, 1933, by A H Smith (33 151), on decayed wood, George Reserve, University of Michigan, Pinckney, May 13, 1933, Smith (33–36)

LACHNUM HYALINELLUM Rehm — On cones of *Picea mariana* (Mill) BSP , Mud Lake Bog, Whitmore Lake, May 28, 1933, Smith (33–106) Isle Royale, 1930, A H Povah (14) This interesting species is characterized by its minute size and the pure white apothecia The paraphyses are conspicuous on account of their shape and size They are broad, sharply pointed, and exceed

[5] *Lachnella tricolor* (Sow) Phill var **microspora**, var nov , a forma typica differt sporis minoribus, 5 5 5 × 1-1 5 μ Specimen typicum in ligno quercino legit A H. Smith prope Ann Arbor, Michigan In Herb Univ Mich conservatum est sub numero 33–151

the asci by fully 20 μ The asci are slender and measure 35–40 × 4–5 μ The hyaline hairs are blunt, of equal diameter, and rough

LACHNUM CLANDESTINUM (Bull) Karst — On fallen leaves of *Vaccinium corymbosum* L , Mud Lake Bog, Whitmore Lake, May 23, 1933, Mains and Smith (M 33–60), same location, May 28, 1933, Smith (33–107) This fungus resembles *Lachnum calyculaeforme* (Schum) Karst var *latebricolor* Rehm, which is reported on *Vaccinium uliginosum* In the variety, however, the paraphyses are said to be in part filiform and in part lance-shaped In *L clandestinum* the paraphyses are conspicuously lance-shaped and taper to slender stalks with the widest part well below the tip The brown hairs are large and rough and are tipped with large crystals They frequently adhere in clusters and, with the crystals gone, give a false appearance of teeth at the margin Our collection seems identical with Sydow's Mycotheca Germanica, No 1006

LACHNUM CARNEOLUM (Sacc) Rehm — On *Eriophorum callithrix* Cham , Mud Lake Bog, Whitmore Lake, May 23, 1933, Smith (33–109), same location, May 28, 1933, Mains (33–672) This delicate fungus measures only about 400 μ in height The apothecium is thin and nearly transparent The very small asci measure only 20–30 × 4–4 5 μ and contain spores 5–6 × 1 5 μ The paraphyses are sparse and extend about 10 μ beyond the asci As Rehm (15) stated, iodine colors the ascus pore and also the tips of the hairs blue *Lachnum Eriophori* (Quél) Rehm, which is reported on *Eriophorum latifolium*, is a much larger fungus

DASYSCYPHELLA CASSANDRAE Tranzs — On living moss, *Sphagnum sp* , dead sticks, Mud Lake Bog, Whitmore Lake, June 11, 1931, Kanouse, on dead sticks of *Chamaedaphne calyculata*, same location, May 28, 1933, Smith, Lowe, and McFarland (S 33–110) The collection from Isle Royale, Michigan, described by Povah (18) as *Erinella borealis* (Fp 497), is identical with those from Mud Lake Bog The paraphyses in all the apothecia examined are filiform The genus Erinella is commonly described as having lance-shaped paraphyses To take care of the Erinella-like fungi with filiform paraphyses Tranzschall (24) established the genus Dasyscyphella and described *D Cassandrae*, which was collected on dead sticks of *Cassandra* (*Chamaedaphne*) *calyculata* in Russia.

Saccardo and Sydow (20) transferred it to Erinella as *E Cassandrae* (Tranzs) Sacc & Syd Rehm, on the contrary, recognized the genus as valid, since he distributed an American collection as *D Vitis* (S) Rehm (Ascomycetes Exsiccati, No 1453) This number was examined by the author and the paraphyses were found to be filiform Clements and Shear (2) also recognize the validity of Dasyscyphella in their classification It seems to the author more logical to consider Erinella and Dasyscyphella distinct genera

Phaeohelotium, gen nov [6] — Apothecia superficial, sessile to stipitate, at first turbinate, opening to a disk, finally convex and slightly umbilicate, soft, waxy, drying brittle to chalky, outside pulverulent, bright-colored, hypothecium thick, prosenchymatous, yellowish, asci cylindrical-clavate, rounded above and thick-walled at the apices, 8-spored, spores ellipsoid to fusoid, straight or slightly bent, 2-celled, brown, paraphyses filiform, colorless, extending beyond the asci, numerous

Phaeohelotium flavum, sp nov [7] (Pl XV, Fig 4) — Apothecia sessile to short-stipitate, superficial, gregarious to caespitose, soft waxy when fresh, chalky to brittle when dry, at first cup-shaped or turbinate, finally opening to a disk, convex and slightly umbilicate or applanate, 1-2 mm broad, 1 1 5 mm high, hymenium bright yellow to orange-yellow, margin white to pale yellow, exterior concolorous, paler at base, delicately pulverulent, hyaline hyphae radiating from the base to the substratum, hypothecium thick, prosenchymatous, the thin exciple formed of large, thin-walled cells, hyaline or faintly yellowish, asci cylindrical-clavate, tapering to a slender base, rounded and thick-walled above, 100-125 × 8-9 μ, 8-spored, the ascus pore colored faintly blue with iodine, spores subfusoid, straight to slightly bent, 2-celled, with 2-4 large oil drops, brown, walls thick and somewhat rough warty,

[6] **Phaeohelotium,** gen nov , sporis uniseptatis, fuscis, alibi ut in Helotio Species typica, *P flavum*, sp nov

[7] **Phaeohelotium flavum,** sp nov , apotheciis sessilibus vel brevissime stipitatis, superficialibus, gregariis, primum subturbinato-cupulatis, deinde convexis 1-2 mm latis disco flavo mox aurantio-flavido, excipulo contexto cum hypothecio prosenchymatoso, ascis cylindrico-clavatis, longe pedicellatis, 100-125 × 8-9 μ, 8-sporis, apices iodo coeruleo-tinctis, sporis subfusoideis, rectis vel curvatis, uniseptatis, fuscis, paraphysibus copiosis, filiformibus Specimen typicum legit E B Mains prope Harbor Springs, Michigan In Herb Univ Mich. conservatum est sub numero 31-895

14–16 × 4–5 μ, paraphyses filiform, hyaline to faintly yellowish, 2–3 μ at the apices, exceeding the asci but not forming a definite epithecium

On decaying log, Harbor Springs, Michigan, Sept 9, 1931 Type collected by Mains (31-895), on oak stump, George Reserve, University of Michigan, Pinckney, Nov 1, 1931, Smith (31–1), on mossy log, Miner's Falls, Munising, Sept 5, 1932, Mains (32-578)

This fungus could quite easily be mistaken for *Helotium citrinum* (Hedw) Fr upon superficial examination The dark color of the spore walls in *P flavum* is developed tardily, so that immature apothecia of the two species bear a close resemblance However, in mature apothecia the spores are dark-colored, with the walls frequently irregularly thickened, so that they are easily distinguished from the hyaline spores of *H citrinum* The spore characters, together with the prosenchymatous hypothecium, place this fungus in the section Phaeodidymeae of the Helotiaceae

The genus Lambertella, described by Von Höhnel (6), has one-celled spores and a sclerotium He (7) erected the genus Phaeociboria for dark-spored species lacking a sclerotium In it he placed *Mollisia tetrica* Quél , which he considered to be "eine kurzteilige Ciboria mit gefärbten Sporen" and he used the name *Phaeociboria Sejournii* (Boud) v H , since he considered *Peziza Sejournii* Jaap merely an immature form of *Mollisia tetrica* One other fungus with dark spores was reclassified by Von Höhnel by the removal of *Belonioscypha malanospora* Rehm to the genus Scelobelonium proposed by him in 1905 This fungus has many-celled spores

PEZIZACEAE

SARCOSPHAERA HINNULEA (B & Br) Massee (Pl XIII, Fig 3) — On *Marchantia polymorpha*, Mud Lake Bog, Whitmore Lake, July 4, 1933, Mains and Smith (M 33–673) Seaver (22) reports this species as growing on the ground Our plants can be referred here, notwithstanding, since they agree in all respects other than that of substratum

PITYA CUPRESSI (Batsch) Rehm (Pl XV) — On leaves of *Juniperus horizontalis* Moench , Botanical Garden, University of Michigan, Ann Arbor, May 27, 1933, Mains (33–61), same location, May 29,

1933, Smith (33–1160), and again Sept 29, 1933, Mains (33–666) The species is not uncommon in certain localities but, so far as we know, this is the first time it has been found in Michigan

OF MICHIGAN

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EXPLANATION OF PLATE XII

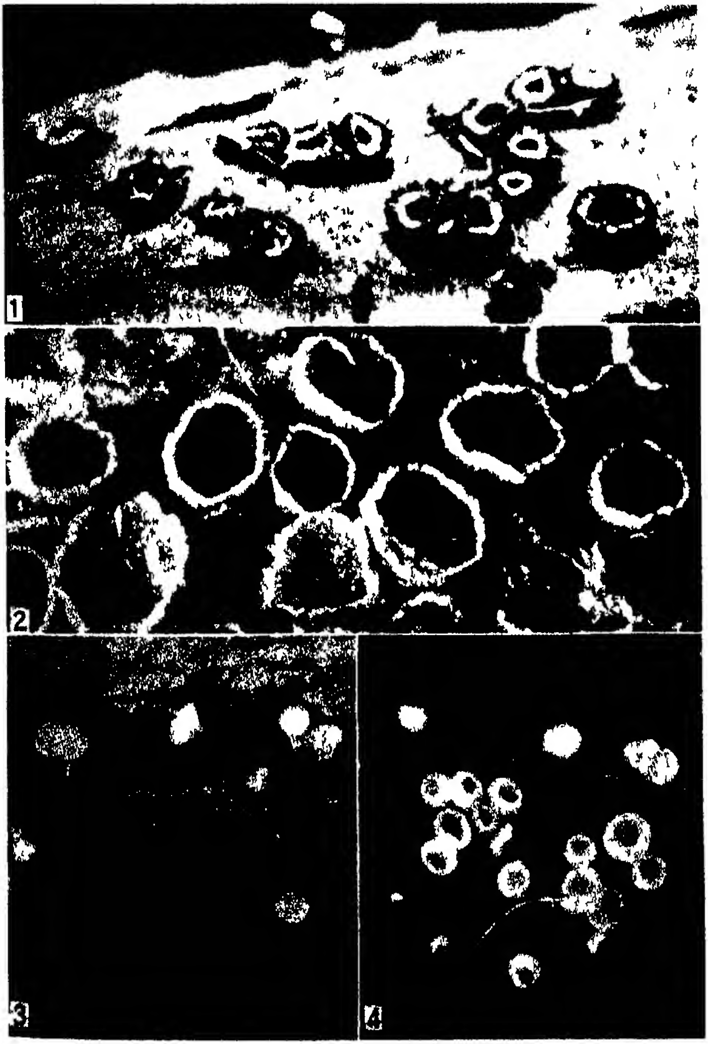
FIG 1 *Pyrenopeziza Artemisiae* (Lasch) Rehm var *Solidaginis* Rehm On decaying stem of a composite × 16 5

FIG 2 *Calloria Solidaginis*, sp nov On dead stems of *Solidago sp* × 16 5

FIG 3 *Phialea acicularum* (Rolland) Rehm On fallen overwintered leaves of *Larix laricina* × 16 5

FIG 4 *Pezizella aspidiicola* (B & Br) Rehm On petioles of *Adiantum pedatum* × 16 5

PLATE XII



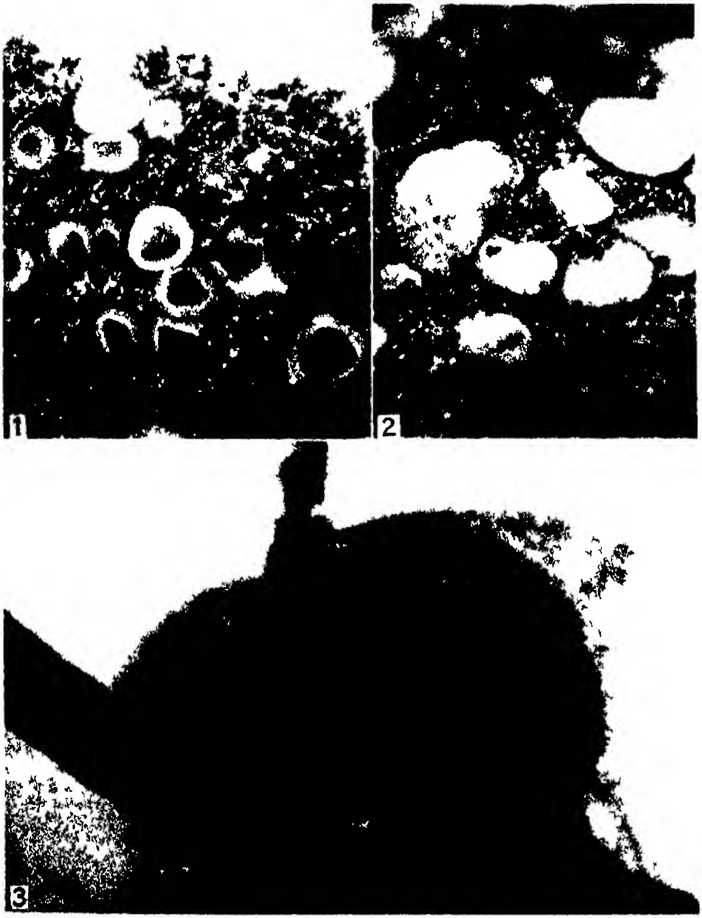
EXPLANATION OF PLATE XIII

Fig. 1. *Tapesia fusca* (Pers.) Fuck. The subiculum is plainly seen. × 16.5

Fig. 2. *Tapesia lividofusca* (Fr.) Rehm var. *fallax* (Desm.) Rehm. × 16.5

Fig. 3. *Sarcosphaera hinnulea* (B. & Br.) Massee. On *Marchantia polymorpha*. × 16.5

PLATE XIII



EXPLANATION OF PLATE XIV

Fig. 1. *Cyathicula coronata* (Bull.) De Not. × 16.

Fig. 2. *Cyathicula Marchantiae* (Sommerf.) Sacc. × 16.

Fig. 3. Asci and ascospores of *Caldesia sabina* (De Not.) Rehm. × 16.

Fig. 4. *Caldesia sabina* (De Not.) Rehm. × 16.

PLATE XIV

EXPLANATION OF PLATE XV

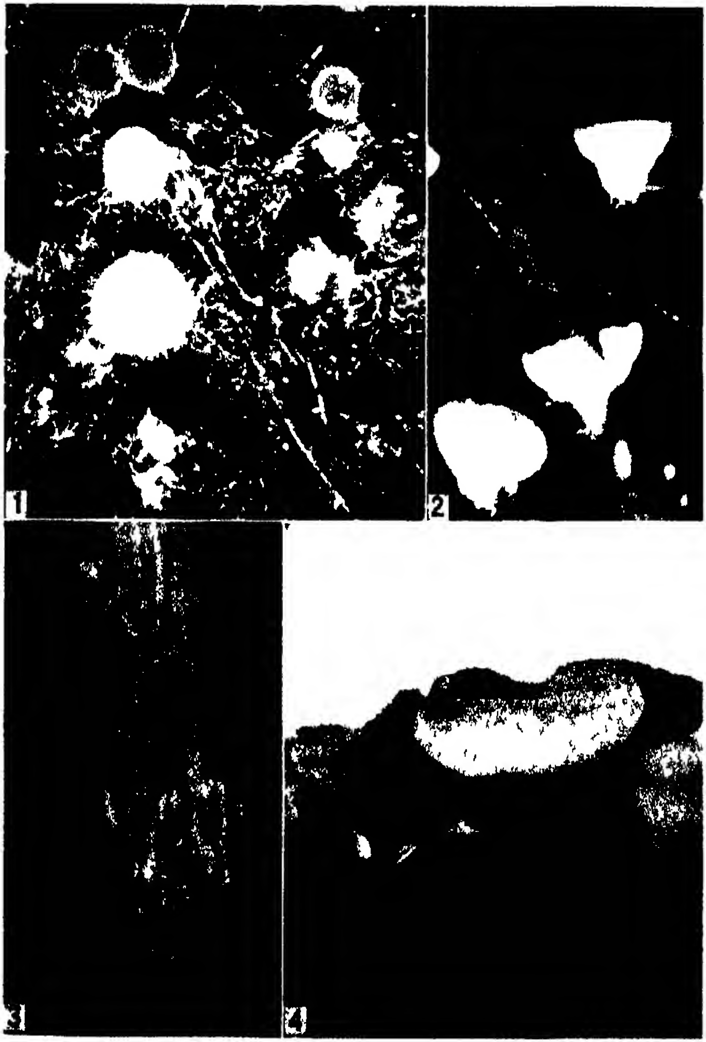
Fig. 1. *Coryneopsis delicatula* (Fuck.) v. H. × 16.5

Fig. 2. *Pitya Cupressi* (Batsch) Rehm. × 16.5

Fig. 3. *Naemacyclus niveus* (Pers.) Fr. On needle of *Pinus sylvestris*. × 16.5

Fig. 4. *Phaeohelotium flavum* gen. nov. et sp. nov. × 11

PLATE XV



A SUPPLEMENTARY NOTE ON LONGEVITY OF *ASPERGILLUS ORYZAE* AND *RHIZOPUS NIGRICANS*

ADELIA McCREA

AMONG the many interesting members of the Aspergilli, *A Oryzae* (Ahlburg) Cohn is outstanding Aside from its botanical characteristics, this species is so versatile for practical purposes that it has long been of great industrial and medical importance Because of its strong diastatic activity it is utilized for the liquefaction of starch in the preparation of such products as sake wine, soja sauce, takadiastase, and polyzime Although it is a native species of Oriental countries it has become widespread through its practical applications and because of the ease with which it can be maintained under ordinary laboratory culture

One characteristic of this species which has interested the writer and to which attention has previously been directed is its persistence of life under adverse conditions In 1919 (1) and again in 1927 (2) living cultures were obtained from a tube of dry "spore dust" of *A Oryzae* that had been collected and sealed in 1897, i e life had persisted thirty years under unfavorable conditions The tube was resealed at once for another five-year interval

In 1932 the tube was again opened for further tests to be made Methods of opening, testing, and resealing followed the former procedure in all essential details Cultures were readily obtained upon a variety of media, thus extending the period of survival of *A Oryzae* to thirty-five years This, so far as the writer knows, sets a record The tube was promptly resealed and should be tested again in 1937, after a lapse of another five years

While the tube was open in 1932 a portion of the contents was transferred to a small sterile tube stoppered only by a cotton plug Transplants were made from this at monthly intervals, but under these conditions survival was not long After six months cultures could no longer be obtained

An additional note may also be given here on the survival time of a culture of *A. Oryzae* upon dried nutrient agar in an ordinary test tube. In 1930 such a culture was reported by the writer (2) to have remained viable for eight years. This can now be extended to ten years for Culture 116 growing on 4 per cent glucose agar medium. Such a transplant consists, of course, of both dried mycelium and conidia, but was planted in the usual way without previous soaking or other treatment.

It is of interest that *Rhizopus nigricans*, unintentionally included in the original sealed tube, was no longer viable in 1932, although it had survived the thirty-year test in 1927.

Considering the three series of tests made with material from the original tube sealed in 1897, it seems clear that (*a*) *Aspergillus Oryzae* can survive under such conditions for thirty-five years or more, and that (*b*) *Rhizopus nigricans*, plus strain, can survive under such conditions for thirty years, but not for thirty-five years.

PARKE, DAVIS & COMPANY
DETROIT, MICHIGAN

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MICHIGAN FUNGI I *

EDWIN B MAINS

RECORDS of the fungi of Michigan have been made from time to time by Longyear (31–33), Pollock and Kauffman (36), Kauffman (18–27), Kauffman and Smith (28), Povah (37–39), Baxter (3–4, 6–7), Kanouse (16–17), Smith (42), and Chapman (11) Other reports are scattered through the literature

During the past two years considerable attention has been devoted to a study of the mycological flora of northern Michigan In August and September of 1932 the writer, accompanied by Mrs Mains, made collections north of Harbor Springs in the Lower Peninsula and between Munising and Marquette in the Upper Peninsula In June, 1933, accompanied by Dr A H Smith and J L Lowe, we made a study of the spring flora of the same areas In August and September of 1933, accompanied by Dr Smith, we collected north of Harbor Springs and in various parts of the Upper Peninsula, principally north of Trout Lake and in the vicinity of Marquette Neither season was specially favorable on account of dry weather However, a surprising number of unusual fungi were collected The agarics are being studied by Dr Smith and the Discomycetes by Dr Bessie B Kanouse and will be reported upon by them in connection with other material A number of the most interesting species in other groups will be discussed here, together with several miscellaneous collections which have been added to the Herbarium of the University of Michigan from time to time and which it seems desirable to list in the records of the mycological flora of the state Unless otherwise indicated the determinations were made by the writer Collection numbers are given in parentheses, those of Smith being preceded by S

APOSTEMIDIUM GUERNISACI (Cr) Boud — In running water, Wagner's Falls, Munising, June 9, 1933, A H Smith (S 33–222),

* Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 470

det B B Kanouse Povah (39) reports this species from Isle Royale also It apparently has been rarely collected in Michigan Durand (13) gives the distribution as New England states and Washington

Apostemidium vibrisseoides (Pk) Boud — On submerged wood, Wagner's Falls, Munising, June 12, 1933, A H Smith (S 33-407) This species apparently has not been previously reported Durand (13) gives the distribution as New Hampshire to New York

Corynetes robustus Durand — On wet soil, north of Newberry, Aug 30, 1933, E B Mains and A H Smith (33-552) This species has been reported by Kanouse (17) from Rock River Durand (13) gives the distribution as Maine to Mississippi

Leotia chlorocephala Schw — Along brook, west of Marquette, Sept 6, 1933, A H Smith and E B Mains (33-611) This is apparently the first report for the state Durand (13) gives the distribution as New Hampshire to Alabama

Leotia stipitata (Bosc) Schröter — On ground west of Marquette, Sept 9, 1932, E B Mains (32-671), Wagner's Falls, Munising, Sept 7, 1933, E B Mains (33-616), along Silver Creek, Emerson, Aug 25, 1933, A H Smith and E B Mains (33-500) This beautiful species has also been reported by Kauffman (18) from Emmet Co and by Povah (39) from Isle Royale

Microglossum olivaceum (Pers) Gill — In sphagnum, north of Newberry, Aug 28, 1933, E B Mains and A H Smith (33-524) This is apparently the first report for the state Durand (13) gives the distribution as the northeastern United States and Ontario

Trichoglossum Farlowii (Cooke) Durand — On ground west of Marquette, Sept 9, 1933, E B Mains (32-670) Apparently the first report for the state Durand (13) gives the distribution as Vermont to Florida and Mississippi

Trichoglossum Walteri (Berk) Durand — Mud Lake, Whitmore, Aug 2, 1929, A. H Smith, det A H S , east of Michigamme, Sept 11, 1933, E. B. Mains (33-644) Apparently not previously reported from the state Durand (13) gives the distribution as New Hampshire to Alabama west to Minnesota

irregularis (Pk) Durand — In cedar swamp east of

Michigamme, Sept 11, 1933, E B Mains (33-640) Povah (39) reports this species also from Isle Royale

Mitrula morchelloides, sp nov — Sporophoribus gracilibus, 18-20 mm longis, pileis pallide fuscis, cylindricis vel ellipsoideis, 1-2 mm longis, 1 mm latis, aliquantulum irregulariter, longitudinaliter sulcatis, stipitibus filiformibus, ascis clavatis, 36-50 × 4-6 μ, apice paululum iodo coeruleo-tinctis, ascosporis fusoideo-ellipsoideis, subinflexis, 5-7 × 2-2 5 μ, paraphysibus filiformibus

In humida terra Specimen typicum in Herbario Michiganensi conservatum, Wagner's Falls, Munising, Michigan, June 12, 1933, E B Mains (33-193)

Sporophores slender, 18-20 mm long, pileus pale brown, cylindric to ellipsoid, 1-2 mm long, 1 mm wide, more or less irregularly longitudinally furrowed, stipe filiform, asci clavate, 36-50 × 4-6 μ, apex staining slightly blue with iodine, ascospores fusoid-ellipsoid, slightly curved, 5-7 × 2-2 5 μ, paraphyses filiform Plate XVI *C*

In wet soil Wagner's Falls, Munising, June 12, 1933, E B Mains (33-193)

This is a dainty little species which is not likely to be found except by careful search It has a very distinctly ridged pileus It somewhat resembles *Mitrula muscicola* P Henn and *M Rehmii* Bres These species, however, have a more cerebroid arrangement of the ridges They are yellow to orange and have larger asci 65-75 × 6-8 μ, and ascospores 10-13 × 2-3 μ (Durand 13)

Vibrissea truncorum Fr — On rotting sticks in cold running water, near Big Garlic River, Big Bay, June 13, 1933, E B Mains and A H Smith (33-199), south of Sand River, June 16, 1933, E. B Mains (33-360) Plate XVI *A* This interesting species has been seldom collected in Michigan Povah (37, 39) has reported it from Vermilion and Isle Royale In 1933 it was found in considerable abundance, especially near Big Bay, where nearly every stick in certain brooks was covered with it

Cryptomyces Pteridis (Fr) Rehm. — On *Pteris aquilina*, Rock River, June 10, 1933, E B. Mains (33-157), Whitefish, June 16, 1933, E. B Mains (33-364), Harbor Springs, Aug 20, 1933, E B Mains (33-464) Plate XVI *D* This is apparently the first report of this species for the state It probably is not an

uncommon parasite on *Pteris aquilina* It is usually collected in the summer on the green fronds when the fungus is immature, occurring as black, oblong, sclerotium-like masses on the fronds It was first located at Rock River in 1932 The locality was revisited in the spring of 1933, and abundant mature material was obtained on the dead overwintered fronds on the ground

KEITHIA THUJINA Durand — On *Thuja occidentalis*, Copper Harbor, Sept 1, 1930, M W Gardner, det G B Cummins, Emerson, Aug 25, 1933, E B Mains (33–492) This parasite caused considerable defoliation of white cedar in the upper Peninsula during the summer of 1933 The asci are two-spored (Plate XVI *B*), and the spores are two-celled, with one cell poorly developed and inconspicuous Durand (14) has discussed the relationship to other species of the genus, and Weir (44) has suggested possible means of control

LOPHODERMIUM JUNIPERINUM (Fr) De Not — On *Juniperus communis*, Ann Arbor, April 22, 1922, L E Wehmeyer, det L E W , Pinckney, July 25, 1933, E B Mains (33–406) This is not an uncommon species on juniper, but apparently has not been reported before from the state

NECTRIA OCHROLEUCA (Schw) Berk — On *Acer saccharum*, north of Ann Arbor, Oct 1931, D V Baxter, det H W Wollenweber This and the next species were attacking trees which had been injured by fire

NEONECTRIA CAESPITOSA (Fuck) Wr — On *Acer saccharum*, north of Ann Arbor, Oct , 1931 D V Baxter, det H W Wollenweber

CLAVICEPS NIGRICANS Tul — On *Eleocharis rostellata*, Pelliston, July, 1932, C D La Rue This is apparently the first report for the state Seaver (41) lists this species only from North and South Dakota

HYPOXYLON GLOMERATUM Cooke — Ann Arbor, May 5, 1922, C H Kauffman, det J H Miller

HYPOXYLON PAPILLATUM E & E — On *Tilia sp* , Ann Arbor, 1921, C H Kauffman, det J H Miller

COLEOSPORIUM SOLIDAGINIS (Schw) Thüm , I — On *Pinus resinosa*, Ann Arbor, June 15 to 24, 1932, E B Mains The aecia of this rust occurs yearly in abundance in a pine plantation of the Forestry School of the University of Michigan, as reported by Baxter (5) He notes that the aecia are associated with rust on

species of Solidago whereas species of Aster in the vicinity are free In the spring of 1932 aecia from this plantation were used to inoculate *Aster ericoides*, *A laevis*, *A lateriflorus*, *A macrophyllus*, *A Novae-angliae*, *A paniculatus*, *Solidago bicolor*, *S canadensis*, and *S sempervirens*, which have been listed as hosts for the species Infection was obtained only on the species of Solidago, this indicates the existence of specialized races in this rust

MELAMPSORA BIGLOWII Thüm, I — On *Larix laricina*, Ann Arbor, May 25, 1933, E B Mains (33–57) Infection of Larix was produced from inoculations with germinating teliospores from *Salix sp*

PHRAGMIDIUM ANDERSONI Shear, II, III — On *Potentilla fruticosa*, George Reserve, Pinckney, Oct 10, 1931, E B Mains (31–844) This species is fairly common in the northern United States and Canada, but apparently has been seldom collected in the state

PUCCINIA ANTIRRHINI Diet & Holw, II, III — On *Antirrhinum majus*, greenhouse of the Botanical Garden of the University of Michigan, Ann Arbor, April 2, 1933, E B Mains Plants being used in rust investigations developed abundant telia Telia in this species are not commonly produced

PUCCINIA ERIGENIAE (Orton) Arth, 0, I, III — On *Erigenia bulbosa*, Ann Arbor, May 15, 1932, G W Fischer, det G W F This is apparently the first report of this species from Michigan Arthur (2) has reported it from London, Canada, and Oberlin, Ohio

PUCCINIA GRAMINIS Pers sp f PHLEI-PRATENSIS, II, III — On *Phleum pratense*, Chatham, Aug 22, 1932, E B Mains (32–206) The telia of the race on timothy are rarely collected

PUCCINIA IRIDIS (DC) Wallr, II, III — On *Iris versicolor*, near Lansing, Oct, 1932, G W Fischer The telia of this rust are rare in the eastern United States (Mains 34) Telia of a portion of this collection were overwintered and when germinating in the spring of 1933 were sown on plants of *Valeriana officinalis*, which Tranzschel (43) has shown to be the aecial host in Russia No infection was obtained This result, taken with previous results (34), indicates that the rust of Iris in the eastern United States differs from the Russian not only in its specialization to species of Iris but also in its aecial host

PUCCINIA PARADOXICA Ricker, III —On *Melica Smithii*, Chatham, Aug 22, 1932 (32–204), Au Train Falls, Forest Lake, Aug 25, 1932 (32–334), Miner's Falls, Munising, Aug 30, 1932 (32–450), Rock River, Sept 1, 1932 (32 497), Au Sable Lake, Grand Marais, Sept 8, 1932, II, Chatham, June 17, 1933 (33–366), Au Train Falls, Forest Lake, June 17, 1933 (33–370) All collections by E B and E E Mains

Puccinia paradoxica was described by P L Ricker (40, p 144) from a collection made by C F Wheeler at "Chatham Station," Michigan, Aug 22, 1900 As Ricker notes, this rust is unique among species of Puccinia on grasses on account of the conspicuous verrucose markings of the teliospores, which take the form of somewhat irregular warts

Previous to 1932 the rust was known only from the type collection One of the objects of the trip to the Upper Peninsula in 1932 was to rediscover this species if possible A search in the vicinity of Chatham soon resulted in the location of grass abundantly rusted By further search the rust was found in a number of localities It usually was restricted to fairly small areas, the largest being a strip of about a mile along the path leading into Miner's Falls east of Munising Also an examination of the phanerogamic collections in the University Herbarium resulted in finding a small amount of the rust on a specimen of *Melica Smithii*, collected at Levering, Emmet Co, July 19, 1920, by J H Ehlers

As in the type collection, all the specimens of 1932 had only telia, in which a few urediniospores occurred After a careful search in the spring of 1933, two small areas of the grass fairly heavily rusted with uredinia were discovered The description of this stage is as follows

II Uredinia hypophyllous in chlorotic spots, oblong or linear, about 0 5–1 0 mm long, orange-yellow, early naked, pulverulent, paraphyses numerous, capitate or clavate-capitate, peripheral, 40–70 μ long with head 16–30 μ broad and stipe 4–5 μ in diameter, the wall thin, about 0 5 μ, uniform, urediniospores ellipsoid or subgloboid, 20–28 × 18–22 μ, wall pale yellow, 2–3 μ thick, moderately echinulate, the pores obscure

PUCCINIA RUBIGO-VERA (DC.) Wint sp. f SECALIS (Erikss & Henn) Carleton, 0, I —On *Anchusa officinalis* and *Lycopsis arvensis*,

Botanical Garden of the University of Michigan, Ann Arbor, Sept 30, 1932, E B Mains (32-853) Rye straw bearing telia of this rust was used to mulch plants of *Anchusa officinalis*, *Cerinthe minor*, *Cynoglossum officinale*, *C pictum*, *Echium vulgare*, *Lycopsis arvensis*, and *Symphytum officinale* in the late summer of 1932 Aecia developed only on *Anchusa officinalis* and *Lycopsis arvensis* This agrees with previous results obtained with this rust

PUCCINIA SORGHI Schw , 0, I — On *Oxalis corniculata*, in a greenhouse of the Botanical Garden of the University of Michigan, May 20, 1932, E B Mains The aecia were produced by inoculating with telia from maize

PUCCINIA VINCAE (DC) Berk , II, III — On *Vinca major* in greenhouse, Grand Rapids, May 19, 1920, G H Coons This is apparently the only record of the rust for the state It has also been reported from Massachusetts

UROMYCES FLECTENS Lagerh , III — On *Trifolium repens*, Ann Arbor, Nov 9, 1931, E B Mains This is apparently the first report for Michigan It is the short-cycled rust correlated with common long-cycled species *Uromyces Trifolii* Arthur (1, p 448) places *U flectens* under *Puccinia nerviphila* (Grognot) Arth and describes pycnia and aecia During 1931 and 1932 this rust was repeatedly inoculated on white clover, with only the production of telia It would appear that there are two species Lagerheim (30, p 36) without question described the short-cycled rust, and it seems best to use his name

AECIDIUM HYDNOIDEUM Berk & Curt , 0, I — On *Dirca palustris*, north of Pinckney, May 28, 1932, E B Mains (32-10) This rust occurred in such abundance that plants of Dirca could be located from a distance by their yellow color Professor Ernst A Bessey tells me he collected this rust in 1919 and 1920 in Gogebic and Alger counties

EOCRONARTIUM MUSCICOLA (Fr) Fitzpatrick — On *Thuidium microphyllum* (det W C Steere), maple woods near Turtle Creek, Bay Shore Drive, Menominee County, Aug 17, 1933, Carl O Grassl (3092). Plate XVII *B* This is the first report of this interesting species for Michigan Fitzpatrick (15) has studied it and has concluded that it belongs in the Auriculariaceae He suggests that it may represent an ancestral form of the rusts

DACROMYCES ELLISII Coker — On *Alnus sp*, Rock River, Sept 12, 1927, D Swartz, det G W Martin

EXIDIA RECISA Fr — Whitmore, Nov 3, 1929, and Quincy, Nov 15, 1929, B B Kanouse, det G W Martin

GUEPINIOPSIS SPATHULARIUS (Fr) Pat — Quincy, Aug, 1921, and Pinckney, July 4, 1930, B B Kanouse, det G W Martin

THELEPHORA CAESPITULANS Schw — On soil in woods, Ann Arbor, Sept 4, 1932, A H Smith (S 32-356), det A H S Burt (8) states that this species is rare

CYPHELLA FASCICULATA (Schw) Berk & Curt — On Salix, Ann Arbor, May 10, 1933, A H Smith (S 33-19), det A H S Povah (39) reports this species for Isle Royale also Burt (9) states that it is common on Alnus, but it has not been frequently collected in the state

CYPHELLA SULPHUREA Batsch ex Fr — On dead, decaying stems of Impatiens, along the Huron River, Ann Arbor, May 19, 1933, Smith, Mains, and Kanouse, det A H Smith Plate XVII *C* Apparently this beautiful species has not previously been reported from Michigan Burt (9) states that it is rare and lists it only from New York

CYPHELLA TILIAE (Pk) Cooke — On rotting wood, Ann Arbor, May 27, 1933, A H Smith (S 33-96), det A H S Plate XVII *A* This apparently has been collected only a few times in Michigan Povah (39) reports it from Isle Royale, and Burt (9) lists a specimen collected by G H Hicks, Michigan State College

PHYSALACRIA INFLATA Pk — On rotten log, north of Harbor Springs, Aug 17, 1933, A H Smith (S 33-654), det A H S This is not an uncommon species, but is not collected frequently There are specimens in the University Herbarium from Bay View, Rock River, Vermilion (Povah, 37), and Washtenaw Co (Kauffman, 20) Its position is uncertain in the classification of fungi It is usually placed in the Clavariaceae Krieger (29), however, states that the hymenium occurs on the lower surface of the pileus, which has obscure folds, and considers that it belongs in the Agaricaceae

TYPHULA PHACORRHIZA (Reich) Fr — Arising from buried sclerotia, Ann Arbor, Oct 23, 1931, E B Mains and A H Smith (31-730)

CLAVARIA CACAO Coker — Cascade Glen, Ann Arbor, Aug 15, 1932,

A H Smith (S 32-299), det A H S This species has the odor of cocoa butter

CLAVARIA CITRICEPS Atk — Lakeland, Sept 19, 1932, A H Smith (S 32–448), det A H S

CLAVARIA FILIPES B & Rav — Under spruce, Ann Arbor, Oct 18, 1931, E B and E E Mains Povah (37) has reported this species for Vermilion

CLAVARIA GRACILLIMA Pk — On rotting leaves, George Reserve, Pinckney, Nov 1, 1931, E B and E E Mains (31–571)

CLAVARIA MUCIDA Pers — With algae on rotting logs, etc , Lakeland, Nov 15, 1931, E B Mains (31–638), Whitmore Lake, Sept 8, 1932, A H Smith, det A H S , Stockbridge, Nov 17, 1931, E B Mains (31–693), east of Marquette, Sept 4, 1932, E B and E E Mains (32–553) Plate XVIII *A* This species has also been reported by Pollock and Kauffman (36) from Ann Arbor On account of its algal association Coker and Couch (12) have suggested that it may be on the way to become a lichen if it is not already one

CLAVARIA OBTUSISSIMA Pk — Cascade Glen, Ann Arbor, Aug 17, 1932, A H Smith (S 32–304), det A H S Povah (39) reports this species from Isle Royale also

CLAVARIA ORNATIPES Pk — On ground in sphagnum, Rock River, Sept 6, 1932, E B Mains (32–606) Plate XVIII *B* This is the first record for Michigan of this somewhat uncommon species Burt (10) places it in Lachnocladium

CYCLOMYCES GREENII Berk — On soil in open woods, Lakeland, July 27, 1932, Sister Sylvia (Messinger), det L E Wehmeyer Plate XIX *B* This is the first record for Michigan of this rather rare species Overholts (35) reports it from Ohio, Minnesota, and Iowa

BOLETUS CLINTONIANUS Pk — Cedar Lake, Sept 24, 1904, C H Kauffman, Bay View, Sept 1, 1905, C H Kauffman, Ann Arbor, Aug 14, 1925, C H Kauffman, Ann Arbor, Nov 13, 1931, E B Mains and B B Kanouse (31–743), Marquette, Sept 5, 1933, E B Mains (33–599)

BOLETUS CYANESCENS Bull — Bay View, July 31, 1905, C H Kauffman, Houghton, July 26, 1906, L H Pennington, det C H Kauffman, Marquette, Aug 27, 1906, C H Kauffman, Ann Arbor, July 16, 1921, Helen Dykeman, det L E Wehmeyer,

Harbor Springs, Sept 13, 1932, E B Mains (32–750) Longyear (33) states that this species is rare in the state

Boletus ornatipes Pk — Houghton, Aug 10, 1906, L H Pennington, det C H Kauffman, Harbor Springs, Sept 15, 1932, E B Mains (32–788) Kauffman (18) has reported this species from Wayne County also

Boletinus cavipes Kalchb — Whitmore Lake, Oct 2, 1929, A. H Smith, Oct 25, 1931, and Oct 3, 1932, E B Mains, Marquette, Sept 10, 1933, E B Mains and A H Smith (33–639) Plate XX *A* Kauffman (18) has reported this species from Washtenaw County also

Boletinus grisellus Pk — George Reserve, Pinckney, Oct 9, 1932, E B Mains (32–865), Marquette, Sept 5, 1933, E B Mains (33–603) Kauffman (18) reported this species from Washtenaw County

Boletinus paluster Pk — Rock River, Sept 6–8, 1927, D Swartz and C H Kauffman, Marquette, Sept 4, 1933, E B Mains and A H Smith (33–596) This species has been reported by Kauffman (18) from Washtenaw County and by Povah (39) from Isle Royale

Gautieria morchelliformis Vill — Cascade Glen, Ann Arbor, Aug 18, 1932, A H Smith (S 32–313) Plate XIX *A* Kauffman (23) collected this rare species in the same locality in Oct, 1910

Phallogaster saccatus Morg — On rotten log, Pinckney, July 17, 1930, B B Kanouse, det B B K Kauffman (20) has reported this species from Ann Arbor and states that it is rare

Hydnangium Fitzpatrickii Zeller & Dodge — Cascade Glen, Ann Arbor, Sept 2, 1912, C H Kauffman, det Zeller and Dodge Zeller in a letter states that this is the second collection of the species

Rhizopogon roseolus (Corda) Zeller & Dodge — Oak woods, Ann Arbor, Oct 2, 1926, Mrs C H Kauffman, det S M Zeller

Melanogaster variegatus (Vitt) Trel — Ann Arbor, Oct 2, 1926, L E Elsvall, Oct 31, 1926, C H Kauffman, Oct 15, 1929, A H Smith All det by S M Zeller

Scleroderma Geaster Fr — George Reserve, Pinckney, Nov 16, 1931, E B and E E Mains, det B B Kanouse Plate XX *B* This species apparently has not been reported previously. Coker

and Couch (12) report this species for Florida, North Carolina, South Carolina, and Tennessee

SPHAEROBOLUS STELLATUS Tode — On rotting logs and débris, Harbor Springs, Sept 10, 1931, E B Mains (31-783), Dexter, Oct 17, 1931, E B Mains (31-787), Ann Arbor, Oct 18, 1931, E B Mains (31-780) This species has also been reported by Kauffman (20) for Washtenaw County and by Povah (39) for Isle Royale

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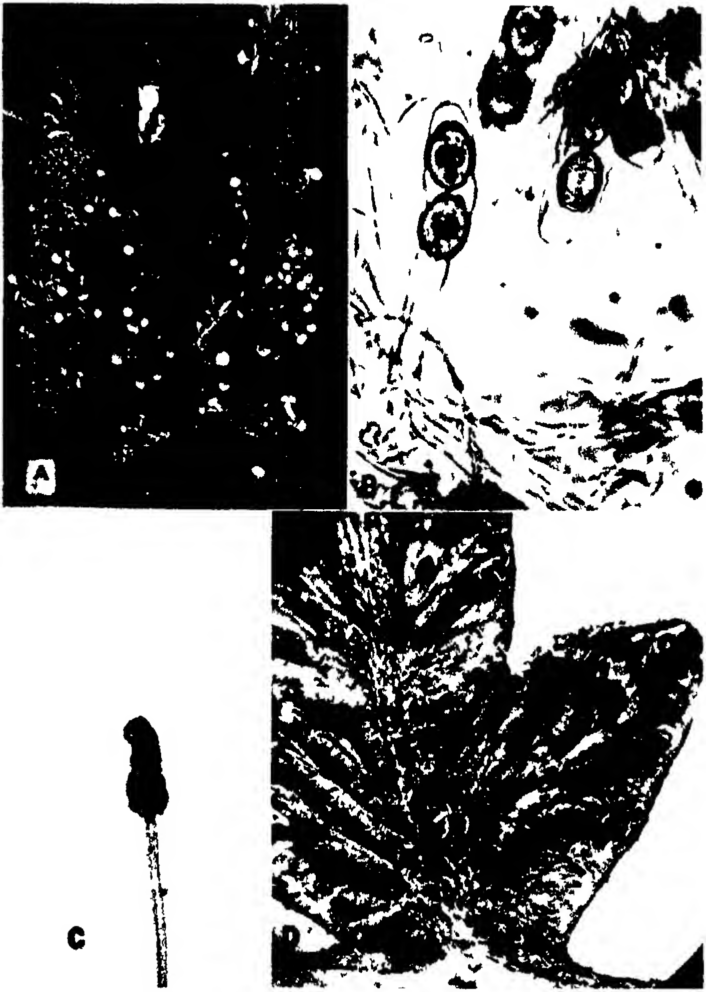
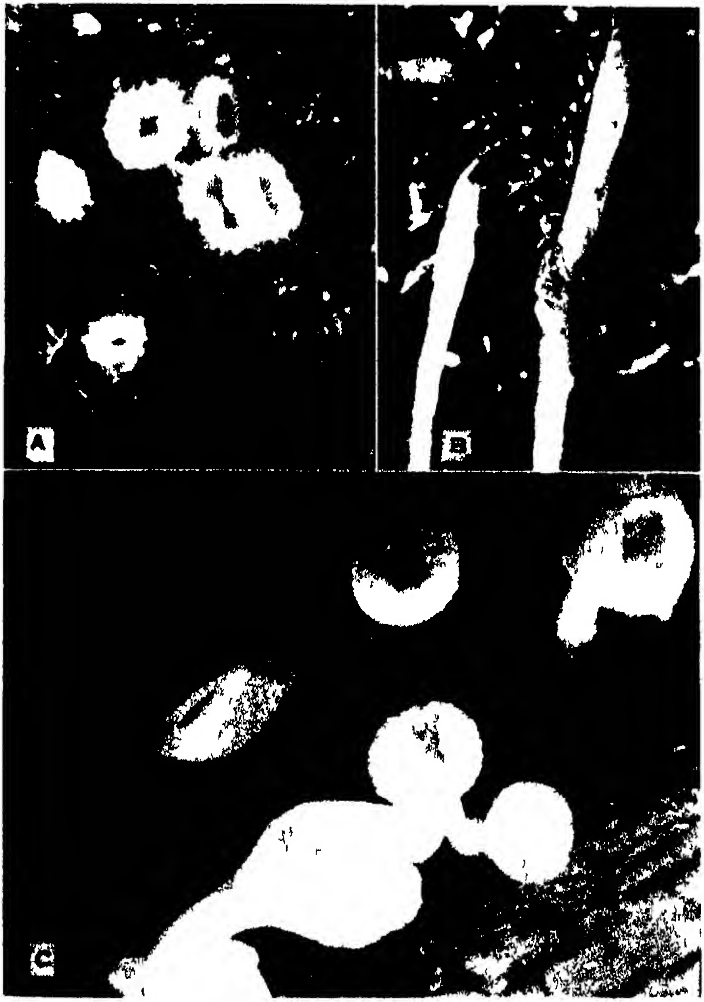
PLATES XVI–XX

PLATE XVI



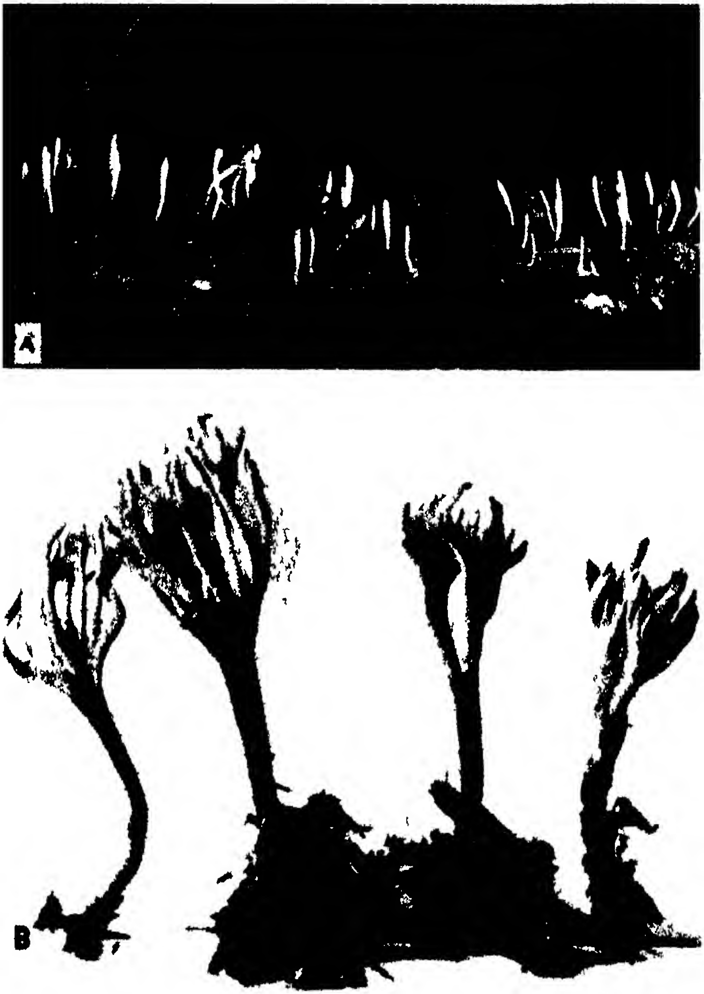
A *Vibrissea truncorum* B *Keithia thujina*
C *Mitrula morchelloides* D *Cryptomyces Pteridis*

PLATE XVII



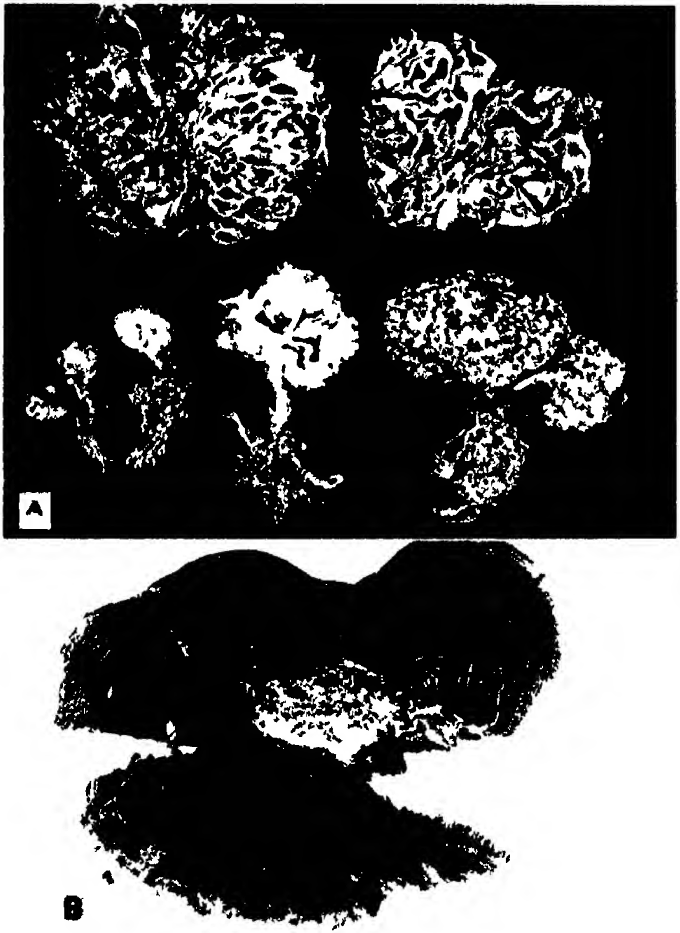
A *Cyphella Tiliae* B *Eocronartium muscicola* C *Cyphella sulphurea*

PLATE XVIII



A *Clavaria muscida* B *Clavaria ornatipes*

PLATE XIX



A *Gautieria morchelliformis* B *Cyclomyces Greenii*

PLATE XX

A *Boletinus cavipes* B *Scleroderma Geaster*

NEW SUMATRAN PLANTS II

ELMER D MERRILL

IN THIS second paper a considerable number of species, originally described from extra-Sumatran material are here recorded from Sumatra for the first time, and the Sumatran ranges of others are extended The first paper of the series appeared in the preceding volume of the *Papers* (19 149–204)

GRAMINEAE

ERIANTHUS DECUS-SYLVAE Ridl, in Journ Malay Branch Roy As Soc., 1 110 1923

Erianthus sumatranus Henr, in Fedde, Repert, 22 349 1926

Sumatra, Tapianoeli, Sibolga to Taroetoeng, *Yates 2533*, April 29, 1927, at the edge of the forest, altitude about 1000 m

I have not seen the type of either species, but rather confidently refer *Yates 2533* to Ridley's species (type from Bĕrastagi), and reduce to it Henrard's species (types from Sibolangit and Habinsaran)

COMMELINACEAE

FORRESTIA IRRITANS Ridl, in Journ. Straits Branch Roy As Soc, 41 38 1904, Fl Malay Penin, 4.361 1924

Sumatra, East Coast, Vale of Tangga, below Adian Langge, Asahan, *Bartlett 7707*, May 12–21, 1927 Previously known only from the Malay Peninsula

PHYTOLACCACEAE

PHYTOLACCA ICOSANDRA Linn, Syst, ed 10, 1040 1759, Sp Pl, ed 2, 631 1762, H Walt, in Pflanzenreich, 39 (IV 83) 60 1909

Sumatra, East Coast, old jungle at edge of clearing near Aek Kanopan, Loendoet Concession, Koealoe, and Tapianoeli, Hoeta Gindjang (northwest of Balige), Toba, *Bartlett 7006, 8334*, March and June, 1927 A widely distributed tropical American species, here introduced and naturalised as it is in Java

ANNONACEAE

DREPANANTHUS PRUNIFERUS Maing, in Hook f, Fl Brit Ind, 1 56 1872, King, in Ann Bot Gard Calcutta, 4 48, Pl 65 1893, Ridl, Fl Malay Penin, 1 37 1922

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 7018*, March 21, 1927 Malay Peninsula

The flowers are immature, the leaves are densely and softly pubescent beneath, varying from glaucescent to ferruginous More complete material may prove that this Sumatran form is distinct from the one in the Malay Peninsula

POLYALTHIA BULLATA King, in Journ As Soc Bengal, 61 (2) 64 1892 (Mater Fl Malay Penin, 1 313 1892), Ann Bot Gard Calcutta, 4 79, Pl 111 1893, Ridl, Fl Malay Penin, 1.55 1922

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 7319*, April, 1927 Malay Peninsula, Borneo

POLYALTHIA DESMANTHA (Hook f & Th) Ridl, in Journ Straits Branch Roy As Soc, 75 6 1917, Fl Malay Penin, 1 49 1922
Unona desmantha Hook f & Th, in Hook f, *Fl Brit Ind*, 1.61 1872, King, in Ann Bot Gard Calcutta, 4 60, Pl 83 1893

Sumatra, East Coast, Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rakmat 362*, February, 1928, Aek Kanopan and Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 6860*, *7286*, March and April, 1927 Malay Peninsula

The pedicels of the Sumatra form are longer than those described for the type, varying from 2 to 5 cm in length

POLYALTHIA STENOPETALA (Hook f & Th) Ridl, in Journ Straits Branch Roy As Soc, 74.6 1917, Fl Malay Penin, 1 50 1922, Finet and Gagnep, in Mém Soc Bot France, 5 42. 1906 (Contrib Fl As Orient, 2 96 1907)
Unona stenopetala Hook f & Th, Fl Ind, 136 1855, King, in Ann Bot Gard Calcutta, 4 61, Pl 85 1893
Uvaria crinita Hook f, Fl Brit Ind, 1 61 1872, King, *op. cit*, 61, Pl 84 1893

Sumatra, East Coast, Goerach Batoe, *Yates 1753, 1951* Malay Peninsula

Xylopia ferruginea (Hook f & Th) Hook f, Fl Brit Ind, 1 83 1872, King, in Ann Bot Gard Calcutta, 4 151, Pl 198 1893, Ridl, Fl Malay Penin, 1 93 1922
Habzelia ferruginea Hook f & Th, Fl Ind, 123 1855

Sumatra, East Coast, Bandar Pooloeh, Asahan, *Yates 2147, 2562* Malay Peninsula, Borneo

CRUCIFERAE

Cardamine africana Linn, Sp Pl, 655 1753, var borbonica (Pers) O Schulz, in Bot Jahrb, 32 415 1903, Koord Exkursionsfl Java, 2 289, Fig 53 1912
Cardamine borbonica Pers, Syn, 2 195 1806
Pteroneurum javanicum Blume, Bijdr, 51 1825
Cardamine javanica Miq, Illus Fl Arch Ind, 17, Pl 10 1871

Sumatra, East Coast, Dĕlĕng Singkoet, north of Bĕrastagi, Karo Plateau, *Bartlett 6573*, February, 1927 Bourbon, Ceylon, Java, the species is widely distributed in the tropics of both hemispheres

CAPPARIDACEAE

Cleome ciliata Schum & Thom, in Dansk Vid Selskabs Skrifter, 4 67 1827 (Beskr Guin Plant, 294 1827), Oliv, Fl Trop Afr, 1 78 1868, Jochems, in Trop Nat, 82, Figs 1–2 1928
Cleome guineensis Hook, Niger Fl, 218 1849

Sumatra, East Coast, Kisaran, Asahan, *Hamel 1501*, October 14, 1928, Soengei Bedjangkar, Batoe Bara, *Rahmat 1418*, September 23, 1928 Tropical Africa, Java, Penang, Singapore

This is a recently introduced weed in Sumatra It was found also in Penang, *Haniff 331*, December, 1928, and in Singapore, *Clemens 22514*, November, 1929, and occurs here and there in Java It is not included in Ridley's *Flora of the Malay Peninsula* Mr Jochems has already recorded it from Sumatra

SAXIFRAGACEAE

Polyosma latifolia Schltr, in Bot Jahrb, 52 135 1914
Polyosma flavovirens Ridl, in Journ Straits Branch Roy As Soc, 75 · 32 1917, Fl Malay Penin, 1 · 686 1922

Polyosma velutina King, in Journ As Soc Bengal, 66 (2) 304 1897 (Mater Fl Malay Penin, 3 304 1897), non Blume

Sumatra, East Coast, Bandar Poelau, *Yates 2594* Malay Peninsula and Borneo

As Ridley notes, the Malay Peninsula form that King ascribed to *Polyosma velutina* Blume is not closely allied to the Javan species, but he overlooked the publication of *Polyosma latifolia* Schltr (1914), which is the same as *P flavovirens* Ridl New to Sumatra

ROSACEAE

PRUNUS WALLICHII Steud, Nomencl, ed 2, 2 404 1841

Cerasus acuminata Wall, List, no 722 1829, *nomen nudum,* Pl As Rar, 2 78, Pl 181 1831

Cerasus integerrima Wall, List, no 722 1829, *nomen nudum*

Prunus acuminata D Dietr, Syn, 3 42 1843, Hook f, Fl Brit Ind, 2 317 1878, Koehne, in Bot Jahrb, 52 296 1915, non Michx

Laurocerasus acuminata M Roem, Syn, 3 92 1847

Prunus integerrima Steud, Nomencl, ed 2, 2 403 1841

Cerasus Wallichii M Roem, Syn, 3 81 1847

Sumatra, East Coast, Dĕlĕng Singkoet, north of Bĕrastagi, Karo Plateau, *Bartlett 8565*, June 24, 1927 Himalayan region to Burma, Siam, Yunnan, and Indo-China

A rather critical comparison of this excellent Sumatran specimen with material from Sikkim, Siam, and Indo-China shows no characters by which I can distinguish it from *Prunus Wallichii* Steud It is clearly not *Prunus Forbesii* Koehne, type from Sumatra, which, incidentally, Hallier f states cannot be distinguished from *Prunus javanica* Miq Possibly *Bartlett 8661*, from the same locality, is referable here, but my specimen has abnormal inflorescences with only very immature buds

LEGUMINOSAE

PITHECELLOBIUM CONTORTUM (Grah) Mart, in Flora, 20 (2) Beibl 114 1837, Prain ex King and Gamble, in Journ As Soc Bengal, 66 (2) 272 1897 (Mater Fl Malay Penin, 3 272 1897); Ridl, Fl Malay Penin, 1 664 1922

Inga contorta Grah, in Wall, List, no 5283 1832, *nomen nudum.*

Sumatra, East Coast, near Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 7579, 7594*, April 30 and May 3, 1927 Malay Peninsula, Penang

RUTACEAE

EVODIA SPECIOSA Reichb f & Zoll ex Teysm & Binn, in Nat Tijdschr Nederl Ind, 29 255 1867, Hochr, Pl Bogor Exsic, 52 1904 (No 110)

Sumatra, East Coast, Goerach Batoe, Asahan, *Yates 1887*, Dĕlĕng Singkoet, north of Bĕrastagi, Karo Plateau, *Bartlett 8663*, June 27, 1927 Java

The Sumatran form apparently has larger fruits than the Javan one, and may eventually be shown to represent a distinct species

MERRILLIA CALOXYLON (Ridl) Swingle, in Philip Journ Sci Bot, 13 338, Pls 5–6 1918, Ridl, Fl Malay Peninsula, 1 354, Fig 36 1922

Murraya caloxylon Ridl, in Journ Straits Branch Roy As Soc, 50 113 1908

Sumatra, East Coast, Silo Maradja, Asahan, *Bartlett 7190, 8451*, April and June, 1927 Malay Peninsula and Siam, the genus is new to Sumatra

PARAMIGNYA ANDAMANICA (King) Tanaka, in Bull Soc Bot France, 75 712 1928

Paramignya armata Oliv var *andamanica* King, in Journ As Soc Bengal, 66 (2) 223 1893 (Mater Fl Malay Penin, 2 465 1893)

Sumatra, East Coast, Damoeli, Koealoe, *Rahmat 1531*, October, 1928. Andaman Islands, Indo-China, Borneo (*Wood 1270* det Tanaka), Sumbawa, new to Sumatra

ZANTHOXYLUM ACANTHOPODIUM DC, Prodr, 1 727 1824, Hook f., Fl Brit Ind, 1:493 1875

Sumatra, East Coast, Bĕrastagi, *Yates 1548*, April 15, 1925

The specimen agrees closely with Indian material and with the published descriptions Subtropical Himalaya and the Khasia Mountains; new to Sumatra.

MELIACEAE

DYSOXYLUM CAULIFLORUM Hiern, in Hook f, Fl Brit Ind, 1 549 1875, C DC, Monog Phan, 1 498 1878, King, in Journ As Soc Bengal, 64 (2) 45 1895 (Mater Fl Malay Penin, 2 533 1895), Ridl, Fl Malay Penin, 1 396, Fig 40 1922

Sumatra, East Coast, old jungle near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 7327*, April, 1927 Malay Peninsula

POLYGALACEAE

POLYGALA PERSICARIAEFOLIA DC, Prodr, 1 326 1824, Chodat, in Mém Soc Phys Hist Nat Genève, 31 (2) 331 1893

Sumatra, East Coast, Simeloengoen, *Yates 1940*, between Tangga and Pardoeaan, Habinsaran, Tapianoeli, *Bartlett 7779*, May, 1927, Dĕlĕng Piso-piso, Karo Plateau, *Bartlett 6534*, January, 1927 India to southern China, Luzon, Java, Timor, and tropical Australia, not recorded from the Malay Peninsula The Sumatran form is apparently the var *Wallichiana* Chodat, *l c*

EUPHORBIACEAE

ACALYPHA BRACHYSTACHYA Hornem, Enum Pl Hort Hafn, 1 1807, Hort Bot Hafn, 2 909 1815, Pax and Hoffm, in Pflanzenreich, 81 (IV 147 XV) 101 1922

Sumatra, East Coast, lower slopes of Dĕlĕng Sibajak, and Kŏban Djahe, Karoland, *Hamel & Rahmat 749*, 676a, June, 1928 Extending from tropical Africa through tropical Asia to southeastern China and Java, but not previously recorded from Sumatra

APOROSA AUREA Hook f, Fl Brit Ind, 5 351 1887, Pax and Hoffm, in Pflanzenreich, 81 (IV 147 XV) 87 1922

Sumatra, East Coast, Marbau, near Bilah Pertama (Parbasiran), *Rahmat 380*, March, 1928, a staminate specimen Malay Peninsula.

BACCAUREA GRIFFITHII Hook f, Fl Brit Ind, 5 371 1887, Pax and Hoffm, in Pflanzenreich, 81 (IV 147 XV). 66 1922

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 7072*, March 24, 1927 Malay Peninsula

BOTRYOPHORA KINGII Hook f, Fl Brit Ind, 5 476 1888, Ridl, Fl Malay Penin, 3 282 1924

Sumatra, East Coast, Silo Maradja, Asahan, *Bartlett 7258*, April, 1927, near Taloen Djoring, *Rahmat 29*, December, 1927, Damoeli, Koealoe, *Rahmat 1527*, October, 1928 Malay Peninsula, Siam

Two of the specimens have male flowers, the others are sterile Ridley in 1924 cited but two collections and stated that the female flowers and fruits are unknown I strongly suspect that the genus belongs in the Euphorbiaceae-Acalypheae-Mercurialinae, although Pax and Hoffman do not admit it in their monographic treatment of 1914[1] As noted by Hooker f in the original description, the structure of the anthers is very characteristic Material with pistillate flowers and fruits is much needed

BRIDELIA RETUSA (Linn) Spreng, Syst, 3 48 1826, Jabl, in Pflanzenreich, 65 (IV 147 VIII) 69, Fig 1F, 12 C–E 1915
Cluytia retusa Linn, Sp Pl, 1042 1753

Sumatra, Tapianoeli near Kota Napan, *Yates 2405*, in open forests and grasslands India and Ceylon to Burma, Siam, and the Malay Peninsula

TRIGONOSTEMON SUMATRANUS Pax & Hoffm, in Pflanzenreich, 47 (IV 147 III) 90 1911

Sumatra, East Coast, Bandar Poeloeh, Asahan, *Yates 1739*, August, 1925, Damoeli, Koealoe, *Rahmat 1514*, October, 1928, near Aek Sordang and Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 6961*, *6969*, *6975*, *7613*, May, 1927, Silo Maradja, near Taloen Djoring, Asahan, *Rahmat 59*, December, 1927, between Bangoen Dolok and Dolok Maradja, Asahan, *Rahmat 1212*, *1225*, September, 1928, *Hamel 1240*, September, 1928

It is apparently this dioecious species that is well represented by the foregoing series of specimens with excellent staminate and pistillate flowers and fruits Pax and Hoffmann's description was based on a fragmentary specimen (*Forbes 2647*) The staminate specimens rather closely approximate *Henry 11947* from Yunnan, the type collection of *Trigonostemon thyrsoideus* Stapf, which, however, Pax and Hoffmann indicate as having glabrous ovaries, in the Sumatran

[1] Pflanzenreich, 63 (IV 147 VII) 1–472, Figs 1–67 1914

material cited above the ovaries are pubescent The pistillate inflorescences are racemose, not paniculate This Sumatran species is apparently very closely allied to *Trigonostemon malaccanus* Muell-Arg of the Malay Peninsula

CELASTRACEAE

CELASTRUS MALAYENSIS Ridl, in Journ Straits Branch Roy As Soc, 75 18 1917, Fl Malay Penin, 1 451 1922.

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 6864*, March 12, 1927, Malay Peninsula

This seems to be the same as the Malay Peninsula form described by Ridley as *Celastrus malayensis*, a form confused with *Celastrus Championi* Benth, but one having much smaller fruits than the Chinese species

ICACINACEAE

GONOCARYUM MELANOCARPUM Hochr, Pl Bogor Exsic, 42 1904 (No 87), Bull Inst Bot Buitenzorg, 22 49 1905

Sumatra, East Coast, Kuala Masihi, Asahan, *Yates 2380,* Dolok Maradja, Asahan, *Rahmat 1482*, October 7–8, 1928

This species was imperfectly described from specimens cultivated in the Botanic Garden at Buitenzorg, Java, origin unknown but evidently from some part of the Netherlands East Indies The Sumatra specimens very closely match *Hochreutiner 87* (Garden number III G 105, 106), except in their apparently smaller fruit, although Hochreutiner gives no fruit measurements A drawing distributed with specimen No 87 shows the fruits to be about 5 5 cm long In the specimens here referred to *Gonocaryum melanocarpum* Hochr the fruits are 2 5 cm long

ELAEOCARPACEAE

ELAEOCARPUS PARVIFOLIUS Wall, List, no 2662 1831, *nomen nudum,* K Muell, Annot Fam Elaeocarp, 24 1849, Mast, in Hook f, Fl Brit Ind, 1 401 1874, Ridley, Fl Malay Penin, 1 310 1922

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, a large tree, *Bartlett 7318*, April, 1927 Malay Peninsula, Borneo,

STERCULIACEAE

Byttneria Curtisii Oliv in Hook, Ic, 18, Pl 1761 1888, King, in Journ As Soc Bengal, 60 (2) 90 1891 (Mater Fl Malay Penin, 1 199 1891), Ridl, Fl Malay Penin, 1 287 1922

Sumatra, East Coast, Masihi, Asahan, *Yates 2640*, Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat 352*, March, 1928, near Aek Kanopan, and Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 7284, 7310, 7341*, April, 1927, Malay Peninsula

Byttneria Jackiana Wall, in Roxb Fl Ind, 2 386 1824, Mast, in Hook f, Fl Brit Ind, 1 376 1874, King, in Journ As Soc Bengal, 60 (2) 92 1891 (Mater Fl Malay Penin, 1 201 1891), Ridl, Fl Malay Penin, 1 287 1922

Sumatra, East Coast, Bandar Poeloeh, Asahan, *Yates 2213*, Malay Peninsula

The generic name is usually spelled *Buettneria*, but Loefling's original spelling is *Byttneria*

VIOLACEAE

Rinorea comosa (King) Merr, in Journ Straits Branch Roy As Soc, Spec No 410 1921

Alsodeia comosa King, in Journ As Soc Bengal, 58 (2) 407 1889 (Mater Fl Malay Penin, 1 51 1889), Brühl and King, in Ann Bot Gard. Calcutta, 5 (2) 127, Pl 146B 1896, Ridl, Fl Malay Penin, 1 133 1922

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 6874*, March 12, 1927, Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat 115*, March, 1928 Malay Peninsula, Borneo

Rinorea Kunstleriana (King) Taub, in Engler and Prantl, Nat Pflanzenfam, 3 (6) 329 1895

Alsodeia Kunstleriana King, in Journ As Soc Bengal, 58 (2) · 401 1889 (Mater Fl. Malay Penin, 1 45 1889), Brühl and King, in Ann Bot. Gard Calcutta, 5 (2) 122, Pl 141 1896, Ridl, Fl Malay Penin, 1 128 1922

Sumatra, East Coast, Bandar Poeloeh, Asahan, *Yates 2049;* Silo Maradja, *Bartlett 6470, 8196*, June, 1927 Malay Peninsula

RINOREA WALLICHIANA (Hook f & Th) O Ktze, Rev Gen Pl, 42 1891

Alsodeia Wallichiana Hook f & Th, in Hook f, Fl Brit Ind, 1 187 1872, King, in Journ As Soc Bengal, 58 (2) 400 1889 (Mater Fl Malay Penin, 1 44 1889), Ridl, Fl Malay Penin, 1 128 1922

Pentaloba macrophylla Wall, List, no 4024 1831, *nomen nudum*

Sumatra, East Coast, Aek na Gerger, between Djoema Tombak and Taratak, Tanah Djawa, Simeloengoen, *Bartlett 8209, 8234,* June 7–8, 1927 Malay Peninsula, Penang, Borneo (Samawang River, near Sandakan, *C Boden Kloss 18655*)

MELASTOMATACEAE

BLASTUS COGNIAUXII Stapf, in Hook, Ic, 24, Pl 2311 1894

Sumatra, East Coast, Adian Langge, Asahan, *Yates 1336, 2355,* near Pargambiran, Asahan, *Bartlett 6735,* February, 1927 Malay Peninsula, Borneo

DISSOCHAETA SUMATRANA Boerl & Koord, in Koord-Schum, Syst Verzeich Herb Koord, II Sumatra, 46 1911 § *Diplostemones*

Frutex scandens, foliis subtus et ramulis et inflorescentiis minute sed distincte consperse lepidotulis, lepidulis castaneis, minutissime stellato-puberulis, glandulas simulantibus, ramis ramulisque teretibus, ultimis circiter 2 mm diametro, foliis subcoriaceis, oblongo-ovatis vel oblongo-lanceolatis, rigidis, acuminatis, basi late rotundatis vel leviter cordatis 3- vel 5-nerviis, 6 ad 10 cm longis, 2 5 ad 4 cm latis, supra nitidis, plerumque in siccitate pallide viridibus, nervis transversalibus subtus perspicuis, rectis, utrinque usque ad 16, petiolo 0 8 ad 1 5 cm longo, paniculis terminalibus, 10 ad 20 cm longis, ramis inferioribus usque ad 6 cm longis, bracteis deciduis, ut videtur parvis, floribus rosaceis, 4-meris, calyce cylindrico-urceolato, 6 mm longo, consperse minute stellato-lepidoto, tubo basi acuto, subcylindrico, 2 ad 2 5 mm diametro, obscure 4-dentato, petalis 4, ovatis, obtusis, 8 mm longis, staminibus 8, inaequalibus, maioribus filamentis 5 mm longis, antheris lanceolatis, acuminatis, 8 mm longis, connectivo postice appendiculato, appendicibus oblongis vel lanceolatis, tenuibus, acuminatis, 1 2 ad 1 5 mm longis,

antice appendicibus 2 setiformibus instructo, setis antheras subaequantibus

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 6900, 6995, 7315*, March and April, 1927

A species allied to *Dissochaeta punctulata* Hook f of the Malay Peninsula, but the scattered indumentum is stellate-lepidote, not furfuraceous

This amplified description is supplied on the assumption that the specimens cited represent *Dissochaeta sumatrana* Boerl & Koord The original imperfect description is as follows "*Dissochaeta sumatrana* Boerl & Koord — Frutex (?) scandens, *D puncticulatae* Hook affinis, tamen calyce glabro puncticulato nec furfuraceo differt Folia ovata 7 × 3 cm Petiolus ½ cm longus Calyx fructiferus 6 mm longus" The type is *Koorders 22330* from Sangkamiang, Central Sumatra The amplified description given above was originally prepared on the assumption that an undescribed species was represented by the recent collections

UMBELLIFERAE

OENANTHE LINEARIS Wall, List, no 586 1829, *nomen nudum*, DC, Prodr, 4 138 1830, C B Clarke, in Hook f, Fl Brit Ind, 2 696 1879

Sumatra, Tapianoeli, Si Makkoek, on the Toba trail north of the Asahan River, *Bartlett 7473*, April 23, 1927 British India

TORILIS ANTHRISCUS (Linn) Gmel, Fl Bad, 1 615 1805
Tordylium anthriscus Linn, Sp Pl, 240 1753

Sumatra, East Coast, Asahan, *Yates 1565*, Tapianoeli, between Panapparan and Pagar Batoe, Habinsaran, *Bartlett 7914*, May, 1927 Widely distributed in Europe and Asia, recorded also from Java, but not known from the Malay Peninsula

PRIMULACEAE

LYSIMACHIA JAPONICA Thunb, Fl Jap, 83 1784, Knuth, in Pflanzenreich, 22 (IV 237) 262 1905

Sumatra, East Coast, between Panapparan and Pagar Batoe, Habinsaran, Tapianoeli, *Bartlett 7895*, May 17, 1927 India to Japan, southward to Luzon and Java, introduced in Australia No representative of the genus is as yet recorded from the Malay Peninsula

LOGANIACEAE

FAGRAEA ACUMINATISSIMA Merr, in Journ Straits Branch Roy As Soc, 77 232 1917, Camel, in Bull Jard Bot Buitenzorg, III, 5 330, Fig 9 1923

Sumatra, East Coast, Bandar Poelau, Asahan, *Yates 2587* Borneo, Banka, the Riouw Archipelago, and the Malay Peninsula

FAGRAEA TEYSMANNII Camel, in Bull Jard Bot Buitenzorg, III, 5 314, Fig 3 1923

Sumatra, East Coast, Damoeli, Koealoe, *Rahmat 1346, 1406*, September, 1928 Previously known from Borneo and the Karamata Islands

APOCYNACEAE

POTTSIA LAXIFLORA (Blume) O Ktze, Rev Gen Pl, 416 1891
Vallaris laxiflora Blume, Bijdr, 1043 1826
Pottsia cantoniensis Hook & Arn, Bot Beechey's Voy, 199, Pl 43 1836, Ridl, Fl Malay Penin, 2 352 1923
Teysmannia laxiflora Miq, in Versl Med Kon Akad Wetensch, 6 194 1857, Fl Ind Bat, 2 455 1856
Parapottsia laxiflora Miq, Fl Ind Bat, 2 1080 1856

Sumatra, Tapianoeli, *Yates 2531*, May 29, 1927 Southern and western China, to the Malay Peninsula and Java

RAUWOLFIA PERAKENSIS King & Gamble, in Journ As Soc Bengal' 74 (2) 424 1907 (Mater Fl. Malay Penin, 4 634 1907), Ridl' Fl Malay Penin, 2 335 1923

Sumatra, East Coast, Vale of Tangga, Asahan, *Bartlett 7726*, May, 1927, Silo Maradja, Asahan, *Bartlett 6379, 7262*, January, April, 1927, near Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 7662a, 7571*, April and May, 1927, Bĕrastagi, Karo Plateau, *Bartlett 6526*, January 30, 1927, Dĕlĕng Koetoe, near Kampong Goersinga, Karo Plateau, *Bartlett 8540*, June 23, 1927, between Maranti and Sawah Sa Batoe Roewan, Habinsaran, *Bartlett 7869*, May, 1927 Malay Peninsula

RHYNCHODIA RHYNCHOSPERMA (Wall.) K Schum, in Engler and Prantl, Nat Pflanzenfam, 4 (2) 173. 1895

Echites rhynchosperma Wall, Pl As Rar, 1 43, Pl. 49 1830
Rhynchospermum Wallichii A DC, Prodr, 8 431 1844
Rhynchodia Wallichii Benth ex Hook f, Fl Brit Ind, 3 667 1882, Ridl, Fl Malay Penin, 2·361 1923

Sumatra, East Coast, between Tanah Datar and Tandjoeng Tiram, Batoe Bara, *Bartlett 7158*, April 10, 1927, Batoe Bara, *Yates 2365*, Goerach Batoe, Asahan, *Yates 1656* India to Indo-China, Hainan, the Malay Peninsula, and the Philippines

Tabernaemontana cylindrocarpa (King & Gamble), comb nov
Ervatamia cylindrocarpa King & Gamble, in Journ As Soc Bengal, 74 (2) 452 1907 (Mater Fl Malay Penin, 4 662 1907), Ridl, Fl Malay Penin, 2 344 1923

Sumatra, East Coast, Damoeli, Koealoe, *Rahmat 1314, 1340, 1375*, September, 1928 Malay Peninsula

There are no mature flowers on my specimens, only immature buds The material agrees closely with the detailed original description except that the follicles, which are 7 cm long and 7 mm thick when dry, are stipitate and long-rostrate, the terminal beak being slender and about 3 cm long

VALLARIS MAINGAYI Hook f, Fl Brit Ind, 3 651 1882, Ridl, Fl Malay Penin, 2 351 1923

Sumatra, East Coast, Kampong Loendoet, Koealoe, *Bartlett 7124*, March 31, 1927 Malay Peninsula

There seems to be little reason for retaining these species, erect shrubs or trees with axillary flowers, in Vallaris, the type of the genus being a very different scandent species, *Vallaris pergulana* Burm f For these arborescent species the generic designation Paravallaris Pierre is available, but it is not clear in my own mind that this group is generically distinct from Kibatalia G Don (Kickxia Blume)

HYDROPHYLLACEAE

WIGANDIA KUNTHII Choisy, in Mém. Soc Phys Hist Nat Genève, 6. 116 1833, DC, Prodr, 10 184 1846, Brand, in Pflanzenreich, 59 (IV 251) 136 1913

Sumatra, East Coast, Bërastagi, *Yates 2022*, Dëlëng Singkoet, Karo Plateau, *Bartlett 6583*, February, 1927

Widely distributed in Mexico and Central America, introduced into other tropical countries as an ornamental plant, and in places naturalized, as it is in Sumatra

LABIATAE

GOMPHOSTEMMA MICROCALYX Prain, in Journ As Soc Bengal, 59 (2) 316 1891, and in Ann Bot Gard Calcutta, 3 251, Pl 84 1890, King and Gamble, *op cit*, 74 (2) 723 1907 (Mater Fl Malay Penin, 4 933 1907), Ridl, Fl Malay Penin, 2 652 1923

Sumatra, East Coast, Bandar Poeloeh, *Yates 1738*, Aek na Gerger, between Djoema Tombak and Taratak, Tanah Djawa, Simeloengoen, *Bartlett 8241*, June 7–8, 1927 Malay Peninsula

The Sumatra specimens very closely approximate Prain's species, to judge from the illustration and descriptions cited The very slender corollas are shorter than in the Malay Peninsula form, attaining a length of only 2 cm

GOMPHOSTEMMA OBLONGUM Wall, List, no 2154, 1830, *nomen nudum*, Benth, in Wall, Pl As Rar, 2 12 1831, Prain, in Ann Bot Gard Calcutta, 3 261, Pl 95 1891, Ridl, Fl Malay Penin, 2 653, Fig 131 1923

Sumatra, East Coast, Bosar Si Pinggan, Asahan, *Hamel 1167*, Běrastagi, Karo Plateau, *Bartlett 6527*, *Yates 1573*, Soebakti, Karoland, *Hamel and Rahmat 670*, June 21, 1928

Burma to Indo-China, the Malay Peninsula, and the Andaman Islands This may be the Běrastagi form referred by Ridley to *Gomphostemma phlomoides* Benth

MOSLA DIANTHERA (Ham) Maxim, in Bull Acad Sci St Pétersb, 20 456 1875, Mél Biol, 9 431 1875

Lycopus dianthera Ham, in Roxb Fl Ind, 1 145 1820

Sumatra, East Coast, Dolok Si Ria-ria, and lalang bench between Tangga and Pardoeaan, Habinsaran, *Bartlett 7431*, *7761*, April and May, 1927

The genus is new to the Malaysian region except for the occurrence of one species in northern Luzon In the absence of flowers I refer this to the Indian form originally described by Hamilton The seeds are, however, reticulate, but not at all flattened, the latter

being a character used by Dunn, *Notes Bot Gard Edinb*, 6 154 1915, for distinguishing *Mosla dianthera* Maxim from *M lanceolata* Maxim, but all my Japanese material of *M punctata* (Thunb) Maxim has reticulate, not at all flattened, seeds It is possible that this Indian and Sumatran form cannot be distinguished from the Japanese-Chinese *Mosla punctata* (Thunb) Maxim, in which case the latter name should be accepted

GESNERIACEAE

TRICHOSPORUM LONGIFLORUM (Blume) O Ktze, Rev Gen Pl, 477 1891

Lysionotus longiflorus Blume, Bijdr, 766 1826

Aeschynanthus longiflorus DC, Prodr, 9 262 1845, C B Clarke, in DC, Monog Phan, 5 32 1883

Sumatra, East Coast, Dělěng Piso-piso, Karoland, *Hamel* and *Rahmat 710*, June, 1928, slopes and summit of Dělěng Baroes, Karoland, *Bartlett 8503*, June, 1927, Dělěng Si Naboen, ascent from Kampong Goeroe Kinajan, Karoland, *Bartlett 8620*, June, 1927, in the United States National Herbarium Malay Peninsula, Borneo, Java

ACANTHACEAE

HYGROPHILA SAXATILIS Ridl, in Trans Linn Soc, Bot, 3 333 1893

Sumatra, East Coast, between Soenggapa and Pargambiran, Asahan, *Bartlett 8156a*, May, 1927 Ceylon, Malay Peninsula, Indo-China, Borneo, and the Philippines

RUELLIA TUBEROSA Linn, Sp Pl, 635 1753

Cryphiacanthus barbadensis Nees, in DC Prodr, 11 197 1847

Sumatra, East Coast, Asahan, Tandjong Batu, *Yates 1832* A native of tropical America, introduced and more or less naturalized here, as it is in parts of India, in Singapore, Borneo, and Java

RUBIACEAE

BORRERIA LAEVIS (Lam) Griseb, Fl Brit West Ind, 1 349 1861, Britton and P Wils, in Bot Porto Rico and Virgin Isl, Sci Surv Porto Rico, 6 255 1925

Spermacoce laevis Lam., Tabl Encycl, 1.273 1791

Sumatra, East Coast, Kisaran, Asahan, *Hamel 1011*, *1080*, Silo Maradja, *Bartlett 6458*

A widely distributed species in tropical America, introduced and naturalized in Sumatra, as it is in Singapore (sea beach at Changi, *Clemens 22512*, November, 1929), Western Java (Backer and Van Slooten, Jav Theeonkr, Pl 205 1924), Philippines, Jolo, *Bur Sci 44416 Ramos and Edaño* (distributed as *Hedyotis sp*), New Guinea (river bank, Marienberg, Sepik River, *Herre 238*, May, 1929), New Britain (seashore, Kokopo, *Herre 173*, April, 1929), and Samoa (on beach, Apia, *Christophersen 470*, November, 1929)

This weed was introduced into Java some time ago, since it is now there widely distributed and locally abundant, according to Backer, *Onkruid Jav Suikerreit*, 674 It has apparently been disseminated recently to other parts of the Old World tropics, where it is now of distinctly wide geographic distribution It does not appear in Ridley's *Flora of the Malay Peninsula*

BORRERIA LATIFOLIA (Aubl) K Schum, in Mart, Fl Bras, 6 (6) 61 1888

Spermacoce latifolia Aublet, Pl Guiane Franc, 1 55, Pl 19, Fig 1 1775

Sumatra, East Coast, Membang Moeda, Koealoe, *Rahmat 1291*, September, 1928

A species widely distributed in tropical North and South America, introduced in Sumatra. It also occurs in waste places in Singapore, *Clemens 22511*, November, 1929, but it is not included in Ridley's *Flora of the Malay Peninsula*

RICHARDIA BRASILIENSIS Gomez, Mem Ipacac, 31, Pl 2. 1801

Richardsonia brasiliensis Hayne, Beschr Arzn Gew., 8, Pl 21 1822, K Schum, in Mart, Fl. Bras, 6 (6) 84, Pl 87 1888, Backer and Van Sloot, Jav Theeonkr, 208, Fig 208 1924

Sumatra, East Coast, Asahan, *Yates 1883* Of recent introduction here, as it is in Java. Widely distributed in the tropics of the New World

CUCURBITACEAE

MELOTHRIA JAVANICA (Miq) Cogn, in DC, Monog Phan, 3 625 1881, Pflanzenreich, 66 (IV 275 I). 129 1916.

Karivia javanica Miq, Fl Ind Bat., 1 (1). 661. 1855.

Sumatra, East Coast, Tanah Djawa, Simeloengoen, *Rahmat 1427*, September 23, 1928 Hainan, Java, Borneo, and Amboina

CAMPANULACEAE

CAMPANUMOEA LANCIFOLIA (Roxb) Merr, Enum Philip Fl Pl, 3 587 1923

Campanula lancifolia Roxb, Fl Ind, 2 96 1824

Campanumoea axillaris Oliv, in Hook, Ic, 18 Pl 1775 1888

Sumatra, East Coast, Soebakti, Karoland, *Hamel* and *Rahmat 763*, June 21, 1928 Central China to Burma and northern Luzon

LOBELIA SUCCULENTA Blume, Bijdr, 728 1826

Lobelia affinis Wall, List, no 1311 1829, *nomen nudum*, G Don, Gen Syst, 3 709 1834, A DC, Prodr, 7 360 1839, C B Clarke, in Hook f, Fl Brit Ind, 3 424 1881, Koord, Exkursionsfl Java, 3 302 1912, Ridl, Fl Malay Penin, 2 200, Fig 89 1923

Lobelia subcuneata Miq, Fl Ind Bat, 2 574 1856

Sumatra, East Coast, Vale of Tangga, Asahan, *Bartlett 7735*, May 12–21, 1927 India to southern China and Malaysia

Blume's species, type from Buitenzorg, Java, has been overlooked in recent literature on the flora of Java A duplicate of the original collection in the herbarium of the New York Botanical Garden, named in Blume's handwriting, is identical with the species currently referred to *Lobelia affinis* Wall The oldest name is here accepted It is possible that the Philippine *Pratia ovata* Elm, *Leafl Philip Bot*, 2 593 1909, should be reduced to Blume's species, mature fruits not seen

COMPOSITAE

ELEUTHERANTHERA RUDERALIS (Sw) Schulz-Bip, in Bot Zeit, 24 239 1866, Britton and Wilson, Bot Porto Rico and Virgin Isl, Sci Surv Porto Rico, 6 308. 1925

Melampodium ruderale Sw, Fl Ind Occ, 1372 1806

Sumatra, East Coast, Kisaran, Asahan, *Hamel 1010*, August 23, 1928, *Rahmat 1036*, August 24, 1928

An introduced weed of tropical American origin, probably first naturalised in Malaysia in the vicinity of Buitenzorg, Java, but now not uncommon in waste places in Singapore, *Clemens 22570*, Novem-

ber, 1929, although not included in Ridley's *Flora of the Malay Peninsula*

In explanation of the accepted name it may be noted that Schulz-Bip gives the reference to *Botanische Zeitung*, 24 164, 165 1866, but though the species is there critically discussed, he does not actually form the binomial *Eleutheranthera ruderalis*, this appears in his reconsideration of the species on page 239 On the basis of his examination of the specimen in the Linnaean herbarium Schulz-Bip reduced Swartz's species to *Eleuranthera prostrata* (Linn) Schulz-Bip "*Eleuranthera* (*Eclipta* Lin !) *prostrata* Sz Bip ! in Linn herbario" However, the specimen in the Linnaean herbarium representing *Eclipta prostrata* Linn (*Verbesina prostrata* Linn) is not the type, was not in the herbarium until some time after 1767, and the specimen is named in Solander's handwriting The Linnaean species was based solely on a reference to *Eupatoriophalacron* Dill , *Hort Elth* , 138, Pl 113, Fig 137 1732, and *Chrysanthemum maderaspatanum* Pluk , *Alm* , 139, Pl 118, Fig 5 1696, both of these represent *Eclipta alba* (Linn) Hassk Swartz's specific name is the correct one for the species, there are numerous synonyms

New York Botanical Garden
Bronx Park, New York

THE FUNGI OF ISLE ROYALE, LAKE SUPERIOR*

ALFRED HUBERT WILLIAM POVAH

FOR many years, in the popular mind, Isle Royale has been shrouded in mystery by newspaper tales of prehistoric races, copper mines, and wild animals. Accurate data were represented by scattered publications of scientists as a result of their occasional visits to the island. The invasion of the moose added popular appeal to it and stimulated the idea of creating it a national park. In order to have adequate and reliable information the Legislature of the State of Michigan made an appropriation for a scientific survey to be conducted under the auspices of the University of Michigan. This report embodies the results of the mycological work of the Isle Royale Survey of 1930.

There has never been published, so far as I have been able to determine, a list of fungi for Isle Royale. Information regarding its fungi consists merely of scattered published records and collections in various herbaria. The task of attempting to make a complete list is a most difficult one, and no one is more aware than I of the possibility and probability of omissions. The first record which I have found of a fungus collected on the island, is a collection of *Melanconis marginalis* (Pk.) Wehm. (*Diaporthe nivosa* Ell. and Holw.), gathered by W. D. Holway in July, 1889, and named by Ellis and Everhart (10). In August, 1891, F. W. Dewart collected at Washington Harbor and the specimens are in the Farlow Herbarium, but Dr. W. H. Weston, Jr., informs me that "unfortunately there is no list and it would be a long job to make a complete list from the specimens." C. E. Allen and S. C. Stuntz collected fungi on the island in 1901, but the only published records that I have located are *Phyllachora Wittrockii* (Erikss.) Sacc., published by Davis (7), and *Merulius niveus* Fr. (3), *Corticium laetum* (Karst.)

* This paper is part of a biological study of Isle Royale authorized by the Fifty-fifth Legislature of the State of Michigan.

Bres , *Hymenochaete corrugata* (Fr) Lév , *H tabacina* (Sowerb) Lév , and *Stereum fasciatum* Schw , published by Burt (4)

That E T Harper and S A Harper collected on Isle Royale is shown by a specimen of *Corticium livido-caeruleum* Karst from the Von Höhnel Herbarium, now in the Farlow Herbarium Furthermore, Rehm (23) described *Plicaria rubrofusca* from Isle Royale material collected by Harper C H Kauffman paid a brief visit to Washington Harbor, Isle Royale, in 1906 and recorded the following species *Polyporus hispidellus* Pk (14), *Amanita tomentella* Kromb , *Cantharellus cibarius* Fr , *Clitocybe infundibuliformis* Fr , *C ochropurpurea*, Berk , *Collybia maculata* A & S , *Cortinarius armillatus* Fr , *C sanguineus* Fr , *C violaceus* Fr , *Hygrophorus Peckii* Atk , *Lactarius cinereus* Pk , *L deliciosus* Fr , *L deceptivus* Pk., *L torminosus* Fr , *L trivialis* Fr , *Omphalia campanella* Fr , *Paxillus involutus* Fr , and *Tricholoma rutilans* Fr (15) With the exception of nine, as given in the annotated list, these species were again collected by the members of the 1930 Survey

Between June 28 and September 22, 1930, approximately twelve hundred collections of fungi were made, the majority by me, the rest by J L Lowe, with the exception of a few specimens which were brought in by the phanerogamic botanists, Messrs C A Brown and J B McFarlin Botany headquarters were established at Rock Harbor Lodge in a four-room cottage, which afforded a laboratory, drying room, and sleeping quarters The territory within a radius of about three or four miles was thus available for intensive collecting Working from this camp, we obtained specimens at the following localities Rock Harbor, Tobin Harbor, Scoville Point, Passage Island, Bat Island, Smithwick Island, Raspberry Island, Mott Island, Monument Rock Trail, Hidden Lake, Moose Lake, Mount Franklin (Sec 21, T 66 N , R 34 W), Blake Point, Duncan Bay, and the vicinity of the old lighthouse

Eleven days were spent in camp on Birch Island, McCargoe Cove, and during this time collections were made on the shores of McCargoe Cove, Brady Cove (Sargent Lake Trail), Chickenbone Lake and its outlet into McCargoe Cove, Sargent Lake, Lake Eva, Pickerel Cove, an island near McCargoe Cove (Sec 15, T 66 N , R 33 W), and Mount Ojibway (Sec 21, T 66 N , R 34 W)

The second camp site (and third station) was at the head of Rock Harbor, where five days were employed in collecting in the

following localities Wallace Lake, at the head of Rock Harbor, Forbes Lake, Benson Lake, Angleworm Lake, and Lake Ritchie

Nine days were spent in working from a camp located at the junction of the outlet of Siskowit Lake and Siskowit Bay During this period collections were made on Ryan Island in Siskowit Lake, on Wright Island in Siskowit Bay, on the shores of Siskowit Lake and Siskowit Bay, and to the north of Hay Bay

A few specimens were collected on Amygdaloid Island, the shores of Todd Harbor, and Todd Cove Through the kindness of Messrs C A Brown and J B McFarlin a few were obtained from the extreme southwestern end of the island, i e from Washington Harbor, Lake Desor, and Lake Feldtmann That part of Isle Royale lying west of about 88° 55′ west longitude was not explored for fungi because of lack of time

Approximately eleven hundred collections have been studied and named, with the result that they have been referred to 230 genera, 515 species, 14 varieties, and 5 forms If we add to these the 10 species reported by previous collectors, but not found by the 1930 Survey, we have a total of 230 genera, 525 species, 14 varieties, and 5 forms of fungi known to occur on Isle Royale It is my belief that this figure does not adequately represent the total number of different fungi on the island One season is altogether too short to exhaust the possibilities of so rich a mycological flora, as this first list of Isle Royale fungi would indicate Approximately one hundred collections require further study before they can be named

It is of considerable interest to note that two new genera of fungi were collected One has been named Alpova by C W Dodge (8), the other Sclerostilbum by the writer (22) The five following new species were obtained· *Alpova cinnamomeus* C W Dodge, *Entomophthora bullata* Thaxt , sp nov ined , *Scutellinia michiganensis* Povah, *Sclerostilbum septentrionale* Povah, and *Septoria Calypsonis* Povah (22). Apparently, 185 species in the following list have not hitherto been recognised as occurring in the state of Michigan

A striking feature of the fungi of Isle Royale is the number of western species that one encounters Examples of such are *Badhamia nitens* Berk., reported from Colorado and Oregon, *Godronia Urceolus* (A & S ex Fr) Karst., reported only from Alaska, *Thelephora scissilis* Burt, from Washington; *Polyporus alboluteus* E & E., common in the Rocky Mountains, *Polyporus hirtus* Quél , reported

by Kauffman from Colorado (16), Oregon (17), and also from Isle Royale (as *P hispidellus* Pk) (14), *Uromyces Jacksonii* Arth and Fromme, reported only from the Pacific Coast, *Uromyces amoenus* Syd , reported only from Idaho, Oregon, Washington, and British Columbia Other species having a northern and western distribution are *Tuber separans* Gilkey (California and Manitoba), *Sphaeronaemella Helvellae* Karst (Manitoba, Alberta, New Hampshire, and Colorado), *Apostemidium Guernisaci* (Crouan) Boud (New England and Washington), and *Puccinia Epilobii* DC (Wyoming, Quebec, and Greenland) *Onygena corvina* A & S has never been reported from the United States, *Stictis Carestiae* (De Not) Rehm, *Melittosporium propolidoides* Rehm, *Gibberidea alnicola* Rehm, and *Nectria peziculа* Speg have apparently not hitherto been recorded for North America

The most evident fungi on Isle Royale are the mushrooms, which occur in great profusion How unfortunate that Kauffman's only visit to the island was during dry weather! Their collection, however, requires so much time because of field notes that it was not possible to collect all the different species observed Thus the seventy-eight kinds in the list do not adequately represent the number of agarics which grow on the island

In spite of careful searching and wide collecting only a single species of smut, *Cintractia caricis* (Pers) Magn , was obtained Rusts, however, were abundant and fifty species were collected, seventeen of which are new to the state The list of Gasteromycetes, which is rather larger than is usual in the north country, contains seven genera, fifteen species, and one variety

Many wood-inhabiting species were collected, including ten of Fomes, twenty-eight of Polyporus, six of Polystictus, eleven of Poria, and seven of Trametes *Fomes pinicola* was exceedingly common, both on conifers and on hardwoods Heart rot of balsam fir was abundant, and the trees, weakened by such infection, are often broken by the wind Since, however, no fruiting bodies of the fungus were present, it was not possible to determine with certainty the cause of the heart rot Moreover, the conifers, especially the balsam firs, were severely injured by leaf cast diseases This material was referred to Dr G D Darker, who identified the causal organisms as follows on balsam, *Lophodermium autumnale* Darker (6), *Hypodermella mirabilis* Darker, and *Bifusella Faullii* Darker,

on pine, *L pinastri* (Schrad) Chev and *L nitens* Darker, and on spruce, *L Piceae* (Fkl) v H With the exception of *L pinastri* all these collections are the first in the state Furthermore, the collections of *L autumnale*, *L nitens*, *Hypodermella mirabilis*, and *Bifusella Faullii* become historical since, in each case, they enter into the species concept

Frequently the quaking aspens were found to be infected with canker-producing fungi Three types were noted In the vicinity of Rock Harbor many trees were seen with cankers bearing fruiting bodies of *Valsa nivea* (Hoffm) Fr *sensu* Ellis At the head of McCargoe Cove and at Rock Harbor *Hypoxylum pruinatum* (Klotzsch) Cke was found producing cankers on *Populus tremuloides* The most serious disease, however, appears to be a canker caused by *Nectria galligena* Bres At the head of McCargoe Cove, in an area of approximately one-half acre, every quaking aspen was infected and about one third of them were killed by this fungus In Plate XXI is shown a typical canker from this area In a few instances this disease was also noted on white birch The mountain ash was frequently found to be infected with *Gymnosporangium Juniperi* Lk In fact, owing to the brilliant color of the infected leaves, the rust cannot be overlooked

I wish to acknowledge my indebtedness to the late Professor Roland Thaxter for extending to me the courtesies of the Farlow Herbarium and Library, where most of the work was done Moreover, for aid in determining this collection of fungi I am indebted to so many that it would take too much space to list all those who have so generously contributed their help The rusts, smuts, Perisporiales, and some leaf parasites were identified by Dr E B Mains, the Poriae, by Dr Dow V Baxter, the Sphaeriaceae, except as indicated in the list, by Dr L E Wehmeyer, the Hysteriaceae, by Dr M L. Lohman, and the Hypodermataceae, by Dr G D Darker Except as otherwise noted in the list determinations are by the writer The specimens have been deposited in the University of Michigan Herbarium I also desire to thank Dr E B Mains and Mr C A Brown for photographs Finally, I record my gratitude to Professor William H Weston, Jr , for making it possible for me to spend a winter in the Laboratory of Cryptogamic Botany at Harvard University

A summary of the list precedes the annotated list of the known fungi of Isle Royale, Lake Superior, and the adjacent islands

OF THE FUNGI OF ISLE ROYALE AND ADJACENT ISLANDS

	Genera	*Species*	*Varieties*	*Forms*
Myxobacteriaceae	1	1	0	0
Myxomycetes	16	30	2	3
Phycomycetes	9	12	0	0
Ascomycetes	91	156	3	2
Basidiomycetes	88	293	9	0
Fungi Imperfecti	26	33	0	0
Total	231	525	14	5

In the following list the asterisk denotes that the fungus has not hitherto been reported as occurring in the state of Michigan

MYXOBACTERIACEAE

*CHONDROMYCES AURANTIACUS (B & C) Thaxt — A single collection on moose dung, on the shore of Chickenbone Lake Cysts 55–60 × 35–50 μ

MYXOMYCETES

ARCYRIA DENUDATA (L) Wettst — On rotten sticks and on log of *Betula alba* L var *papyrifera* (Marsh) Spach, Moose Lake, McCargoe Cove, Chickenbone Lake

ARCYRIA INCARNATA Pers — On rotten wood of Alnus and *Thuja occidentalis* L, Rock Harbor, Tobin Harbor, McCargoe Cove, and Siskowit Bay

ARCYRIA NUTANS (Bull) Grev — On rotten logs and decaying white birch, McCargoe Cove, Sargent Lake, and Siskowit Bay

BADHAMIA LILACINA (Fr) Rost — A single collection on grass at Forbes Lake

*BADHAMIA NITENS Berk — On birch and conifer logs, Tobin Harbor and Smithwick Island This species is reported from Colorado and Oregon

CERATIOMYXA FRUTICULOSA (Müll) Macbr — On conifer log, Tobin Harbor

*CRIBRARIA MACROCARPA Schrad — On conifer, Tobin Harbor

DIDERMA EFFUSUM (Schw) Morg var RETICULATUM Rost. — On leaves in swamp, Passage Island

*DIDERMA GLOBOSUM Pers. — On leaves and grass, Passage Island. Macbride (18) points out that in the past this species has been much confused with *D. crustaceum* Pk, from which it can be distinguished by its smaller spores.

DIDERMA SPUMARIOIDES Fr — On *Lycopodium sp* and on *Dicranella sp*, Passage Island

DIDYMIUM MELANOSPERMUM (Pers) Macbr — On rotten wood and on bark of *Abies balsamea* (L) Mill, McCargoe Cove

DIDYMIUM SQUAMULOSUM (A & S) Fr — On dead leaves, sticks, and grass, Tobin Harbor, at the outlet of Chickenbone Lake, and McCargoe Cove

FULIGO CINEREA (Schw) Morg — On stick and on *Picea sp*, McCargoe Cove and Lake Ritchie

FULIGO SEPTICA (L) Gmel Form a *F ovata* (Schaeff) Pers — On *Sphagnum sp*, log of *Populus tremuloides* Michx, and moss-covered log, Lake Eva and Tobin Harbor, Form c *F laevis* Pers — On poplar stump, at the head of Tobin Harbor, Form e *F violacea* Pers — On birch log, Tobin Harbor Four other collections are not referable to any special named form They were collected at Tobin Harbor, McCargoe Cove, and on Bat Island

FULIGO SEPTICA (L) Gmel var CANDIDA R E Fries — A single collection, on a dead leaf found on the Sargent Lake Trail from McCargoe Cove, seems to be referable to this variety as given in Lister rather than to any form given by Macbride (*l c*)

*HEMITRICHIA OVATA (Pers) Macbr — On dead *Thuja occidentalis* L, Siskowit Lake Rare Det by G W Martin

HEMITRICHIA VESPARIUM (Batsch) Macbr — On white birch stub, Siskowit Lake

*LAMPRODERMA VIOLACEUM (Fr) Rost — On moss and liverworts and on arbor vitae log, Passage Island and Siskowit Lake

LEOCARPUS FRAGILIS Rost — On white birch twigs and on rotten alder, Moose Lake, Rock Harbor, and McCargoe Cove

LYCOGALA EPIDENDRUM Fr — On rotten wood and dead alder, Benson Lake and Rock Harbor

MUCILAGO SPONGIOSA (Leyss) Morg — One collection on alder twigs, common on stems and leaves at Sargent Lake

*PHYSARUM CINEREUM Pers — On leaves and stems of *Coptis trifolia* (L) Salisb and *Linnaea borealis* L, McCargoe Cove, and on moss on Passage Island

PHYSARUM CONTEXTUM Pers — On moss-covered log, Passage Island

*PHYSARUM RUBIGINOSUM Fr — Four collections on moss, leaves, and twigs at Rock Harbor

*PHYSARUM SINUOSUM (Bull) Weinm — On *Sphagnum sp* , Passage Island, and on base of tree near the outlet of Chickenbone Lake

*PHYSARUM VIRESCENS Ditmar — On moss and balsam fir needles, Rock Harbor, and on moss near Lake Eva

STEMONITIS AXIFERA (Bull) Macbr — Common, on birch, spruce, and pine logs, Rock Harbor, Tobin Harbor, Moose Lake, McCargoe Cove, and Chickenbone Lake

STEMONITIS FUSCA (Roth) Rost — On birch, mountain ash (?), and balsam fir logs, Passage Island, Rock Harbor, and Tobin Harbor

*TRICHIA FLORIFORMIS (Schw) G Lister (*T lateritia* Lev) — On the under side of coniferous log, north of Hay Bay

TRICHIA VARIA (Pers) Rost — On sticks and soil beside brook forming the outlet of Chickenbone Lake

TUBIFERA FERRUGINOSA (Batsch) Gmel — Common on moss and coniferous logs, Tobin Harbor, Passage Island, and McCargoe Cove

PHYCOMYCETES

ABSIDIA GLAUCA Hagem — Isolated from soil, Siskowit Bay

ENDOGONE PISIFORMIS Lk (*E sphagnophila* Atkins) — A single specimen, on tips of Sphagnum, was collected at Rock Harbor

Entomophthora bullata Thaxt , sp nov ined — On "bluebottle" flies on tips of grass, Rock Harbor Coll by C A Brown In 1931 Dr Thaxter determined this collection, saying that the species was common on "bluebottle" and other flies Subsequent to Dr Thaxter's death the writer wrote to Dr Weston to learn whether any manuscript description was left by Thaxter Dr Weston replied "We searched through Dr Thaxter's notes and found no manuscript description of *Entomophthora bullata*, but in his collection of slides he has labeled this *Entomophthora bullata*, n sp , and similarly labeled a small bottle of material You will be quite justified, then, in using Dr Thaxter's name as n sp ined " In view of these facts it seems wise to record that Thaxter told the writer that the conidia of *E bullata* are indistinguishable from those of *E americana* Thaxt The present collection shows only hyphal bodies and the very characteristic subglobose, bullate zygospores, which measure 33–50 μ in diameter

ENTOMOPHTHORA CULICIS A. Br — On tiny insects on dock piling, Rock Harbor

*ENTOMOPHTHORA GRYLLI Fres — On *Melanopus femur-rubrum*, Rock Harbor, Sargent Lake, and Passage Island

ENTOMOPHTHORA RHIZOSPORA Thaxt — Both conidial and zygosporic stages were found on insects in a swamp at Rock Harbor

PERONOSPORA PARASITICA (Pers) DeBy — On *Arabis Drummondii* Gray at Rock Harbor

PHYSODERMA MENYANTHIS DeBy — On *Menyanthes trifoliata* L, Rock Harbor

PILOBOLUS CRYSTALLINUS (Wiggers) Tode — On moose dung, Sargent Lake and McCargoe Cove

SAPROLEGNIA sp — On dead fish, at the head of Rock Harbor Dr B B Kanouse writes "The material does not warrant specific determination"

*SPINELLUS FUSIGER (Lk) Van Tiegh — On old agaric, Tobin Harbor, on *Mycena sp*, Smithwick Island

SPORODINIA GRANDIS Lk — Common on agarics such as *Omphalia sp* and *Lactarius vellereus* Fr, and on *Clavaria pistillaris* (L) Fr Tobin Harbor, Siskowit Bay, McCargoe Cove, and Lake Eva These three hosts are not given by Seymour (26) Engler and Prantl (11), however, mention Clavariaceae and Agaricaceae

ASCOMYCETES

GYMNASCALES

*GYMNASCUS REESII Baranet (?) — On leaves under moose fur, Hidden Lake (Tobin Harbor) Asci 6 8–7 × 5–5 6 μ, spores lenticular, 3 4–3 7 × 1 5–2 μ

PERISPORIALES

ERYSIPHE CICHORACEARUM DC — On *Scutellaria latifolia* L, at the west end of Siskowit Lake

ERYSIPHE POLYGONI DC — On *Caltha palustris* L, Passage Island, on *Chelone glabra* L and *Ranunculus acris* L, McCargoe Cove, and on *Trifolium pratense* L, Rock Harbor

MICROSPHAERA ALNI (DC) Wint — On *Alnus sp*, at the outlet of Siskowit Lake

PHYLLACTINIA CORYLEA (Pers) Karst — On *Cornus stolonifera* Michx., in old burned area, Siskowit Bay, and on leaves of white birch seedling, at the outlet of Siskowit Lake

UNCINULA CIRCINATA Cke & Pk — On *Acer spicatum* Lam , at the outlet of Siskowit Lake

UNCINULA SALICIS (DC) Wint — On leaves of *Populus balsamifera* L , Sargent Lake

SPHAERIALES

SPHAERIACEAE

*CRYPTOSPHAERIA POPULINA (Pers) Sacc — On bark of dead poplar, Rock Harbor

*DIATRYPE BULLATA (Hoffm) Fr — On alder, Rock Harbor, and at the west end of Siskowit Lake

DIATRYPELLA DISCOIDEA Cke & Pk var ALNI Pk — On alder, Rock Harbor and Passage Island

*EUTYPELLA ALNIFRAGA (Wahl) Fr — On dead alder, at the head of Tobin Harbor and Rock Harbor

*EUTYPELLA RUGULOSA (Nit) Sacc — On dead white birch, Rock Harbor

VALSA BOREELLA Karst — On *Populus tremuloides*, at the head of Tobin Harbor

*VALSA KUNZEI Fr — On recently killed *Abies balsamea*, north of Hay Bay

VALSA NIVEA (Hoff) Fr *sensu* Ellis — On cankers of *Populus tremuloides*, Rock Harbor and Mott Island

*GNOMONIELLA CORYLI (Batsch) Sacc var SPIRALIS Pk — On *Corylus rostrata*, Ait , La Sage Lake Coll by C A Brown Plate XXII, Figures 2–3

*CRYPTOSPORA ALNICOLA v H — On alder in old burned area, Siskowit Bay

DALDINIA CONCENTRICA (Bolt) Ces. & De Not — On alder and white birch, Tobin Harbor, Todd Harbor, Forbes Lake, and Siskowit Lake

HYPOXYLUM FUSCUM (Pers) Fr — Common on alder, Rock Harbor, Scoville Point, and Lake Ritchie

HYPOXYLUM MORSEI B & C — On dead alder, Smithwick Island

HYPOXYLUM MULTIFORME Fr — Common on birch and alder, Rock Harbor, Smithwick Island, Tobin Harbor, Raspberry Island, and at the outlet of Siskowit Lake.

HYPOXYLUM PRUINATUM (Klotzsch) Cke — On *Populus tremuloides*, at the head of McCargoe Cove and at Rock Harbor

*HYPOXYLUM RETICULATUM Karst, var ? — On *Fomes pinicola* (Schw) Cke, at Moose Lake, near Tobin Harbor

*HYPOXYLUM RUBIGINOSUM (Pers) Fr — On bark of dead willow, Sargent Lake Det by J H Miller

*DIDYMELLINA IRIDIS (Desm) v H — Causing leaf spots on *Iris versicolor* L, Rock Harbor

*MYCOSPHAERELLA CHIMAPHILAE E & E — Parasitic on *Pyrola secunda* L, Tobin Harbor

*MYCOSPHAERELLA LYCOPODII (Pk) Hse — On sporophylls of *Lycopodium annotinum* L, McCargoe Cove, on leaves of *L annotinum*, Tobin Harbor

VENTURIA CASSANDRAE Pk — On leaves of *Chamaedaphne calyculata*, Rock Harbor

*VENTURIA DICKEI (Berk & Br) Ces & De Not (?) — On *Linnaea borealis*, Tobin Harbor Determination not certain, since no spores were found

APIOSPORINA COLLINSII (Schw) v H — Producing witches'-brooms on *Amelanchier sp*, McCargoe Cove

*MELANCONIS MARGINALIS (Pk) Wehm — On *Alnus crispa* (Ait) Pursh, Angleworm Lake and Rock Harbor, also by W D Holway

MELANCONIS STILBOSTOMA (Fr) Tul — Only the conidial stage (*Melanconium sphaeroideum* Lk) was found, Rock Harbor

*MELANCONIS THELEBOLA (Fr) Sacc — On dead alder, at the head of Tobin Harbor

*DIAPORTHE IMPULSA (Cke & Pk) Sacc — On mountain ash, at the outlet of Chickenbone Lake

DIAPORTHE NIVOSA Ell & Holw — Collected only by Holway (10)

AMPHISPHAERIA THUJINA (Pk) Sacc — On decorticated arbor vitae, Rock Harbor

*GIBBERIDEA ALNICOLA Rehm — On old hardwood stick, probably alder, Rock Harbor Coll by J L Lowe Wehmeyer writes "Rehm [24] gives the spores as 12–15 × 4 5–5 μ, subclavate, and straight The spores of this collection are 12 5–15 (18) × 4–5.5 μ and many are slightly curved Moreover, the perithecial clusters are larger than those given in Rehm's description This collection may be a variety of Rehm's species and may equally

well be placed in the genus Rosenscheldia of the Dothidiales, but in the absence of Rehm's material no definite conclusion can be reached "

*GIBBERIDEA TURFOSA Syd — On dead stems of *Chamaedaphne calyculata* (L) Moench, Rock Harbor, on dead stems of *Ledum groenlandicum*, Rock Harbor

LEPTOSPHAERIA CREPINI (Westd) De Not — On strobili of *Lycopodium annotinum*, Passage Island, on strobili of *L obscurum* var *dendroideum* (Michx) D C Eaton, Wallace Lake

LEPTOSPHAERIA LYCOPODICOLA (Pk) Sacc — On strobili of *Lycopodium annotinum*, McCargoe Cove

*MELANOMMA ASPEGRENII (Fr) Fkl — On rotten white birch log, Rock Harbor

*THYRIDIUM LIVIDUM (Pers) Sacc — On coniferous (white pine ?) log over brook, McCargoe Cove Det by M L Lohman

HYPOCREACEAE

CLAVICEPS PURPUREA (Fr) Tul — On *Calamagrostis sp* and *Agopyron tenerum* Vasey, Rock Harbor, on *Glyceria borealis* (Nash) Batchelder, McCargoe Cove, and on *Calamagrostis canadensis* (Michx) Beauv , between Forbes Lake and Benson Lake

CORDYCEPS CLAVULATA (Schw) E & E — On *Lecanium sp* (scale insect), infesting *Fraxinus nigra* Marsh, beside stream forming the outlet of Chickenbone Lake

CORDYCEPS MILITARIS (L) Lk — On remains of chrysalis in low, wet woods, Sargent Lake

CORDYCEPS OPHIOGLOSSOIDES (Ehr) Lk — Parasitic upon *Elaphomyces granulatus* Fr , Angleworm Lake

*CREONECTRIA PURPUREA (L) Seaver — On alder in swamp, Rock Harbor

*ELEUTHEROMYCES SUBULATUS (Tode ex Fr) Fkl — On old agaric, Siskowit Lake

HYPOMYCES AURANTIACUS (Pers ex Fr) Tul — On old *Polyporus elegans* Bull ex Fr , McCargoe Cove

HYPOMYCES CHRYSOSPERMUS (Bull) Tul — Only the imperfect stage (*Sepedonium chrysospermum* Fr) was found growing upon *Alpova cinnamomeus* Dodge along a brook forming the outlet of Siskowit Lake The Tulasnes (27) record it for Boletus, Scleroderma, Melanogaster, and Octaviana

HYPOMYCES LATERITIUS (Fr) Tul (?) — Parasitic upon the gills of *Lactarius deliciosus* Fr The material is too immature for certain specific determination

NECTRIA EPISPHAERIA (Tode) Fr — On *Hypoxylum sp*, Rock Harbor

*NECTRIA GALLIGENA Bres — Causing a serious large black canker on *Betula alba* var *papyrifera* (Marsh) Spach , near Benson Lake An epidemic of this same disease on *Populus tremuloides* was observed at the head of McCargoe Cove Here every tree was infected and a mortality of approximately thirty per cent was noted The typical canker has a black-ribbed surface, which is bordered by the wide-flaring bark, as shown in Plate XXI

*NECTRIA PEZICULA Speg — On old decaying moose antler on sedge mat at Moose Lake near Tobin Harbor Coll by J L Lowe

*SCOLECONECTRIA SCOLECOSPORA (Bref) Seav — On *Abies balsamea*, Smithwick Island

DOTHIDIALES

DOTHIDIACEAE

PHYLLACHORA TRIFOLII (Pers ex Fr) Fkl — On *Trifolium pratense* L , Rock Harbor Only the imperfect stage (*Polythryncium Trifolii* Kze) was found Det by E B Mains

PHYLLACHORA WITTROCKII (Ericks) Sacc — On stems of *Linnaea borealis*, Moose Lake, near Tobin Harbor Davis (7) reports this fungus for Wisconsin and Isle Royale, the latter collection having been made in 1901 by Allen and Stuntz

PLOWRIGHTIA MORBOSA (Schw) Sacc — On *Prunus sp* , Rock Harbor, on *Prunus pennsylvanica*, in old burned area, Siskowit Lake

PHACIDIALES

HYSTERIACEAE

*HYSTERIUM PULICARE Pers ex Fr — On poplar bark on open ridge, Rock Harbor

HYSTEROGRAPHIUM MORI (Schw) Rehm f CINERASCENS (Schw) Lohman — On decorticated poplar, Rock Harbor

*HYSTEROGRAPHIUM MORI (Schw) Rehm f GERARDI (Cke & Pk) Lohman — On decorticated *Populus tremuloides*, Rock Harbor

*MYTILIDIUM THUJARUM (Cke & Pk) Lohman (*Hysterium thujarum*

Cke & Pk) — On arbor vitae, near old lighthouse, Rock Harbor, and at the outlet of Siskowit Lake

PHACIDIACEAE

*BIFUSELLA FAULLII Darker — On *Abies balsamea,* Raspberry Island Det by G D Darker

*HYPODERMELLA MIRABILIS Darker — On leaves of *Abies balsamea,* Rock Harbor Det by G D Darker

*LOPHODERMIUM AUTUMNALE Darker — On living leaves of *Abies balsamea,* Raspberry Island Det by G D Darker

*LOPHODERMIUM MACULARE (Fr) De Not — On *Vaccinium uliginosum* L , Scoville Point Det by E B Mains

*LOPHODERMIUM PICEAE (Fkl) v H — Causing leaf cast of *Picea canadensis* (Mill) BSP , Rock Harbor Det by G D Darker

*LOPHODERMIUM NITENS Darker — On *Pinus Strobus* L , Rock Harbor Det by G D Darker

LOPHODERMIUM PINASTRI (Schrad) Chev — On *Pinus Strobus,* Lake Harvey, and on *P Banksiana* Lamb , Rock Harbor Det by G D Darker

LOPHODERMIUM SPHAERIOIDES (A & S ex Fr) Duby — On overwintered leaves of *Ledum groenlandicum* Oeder , Rock Harbor Det by E B Mains

*LOPHODERMIUM TUMIDUM (Fr) Rehm — On overwintered leaves of *Sorbus americana* Marsh , Smithwick Island Det by E B Mains

*COCCOMYCES HIEMALIS Higgins (?) — On *Prunus pennsylvanica,* McCargoe Cove

RHYTISMA ANDROMEDAE (Pers) Fr — On leaves of *Andromeda glaucophylla* Lk , Monument Rock Trail from Tobin Harbor

*RHYTISMA PUNCTATUM (Pers) Fr — On *Acer spicatum,* Wright Island, in Siskowit Bay

RHYTISMA SALICINUM (Pers) Fr — On *Salix sp* , at the head of Rock Harbor, and in an old burned area at Siskowit Bay Det. by E B Mains

STICTIDIACEAE

*MELITTOSPORIUM PROPOLIDOIDES Rehm — On branch of *Thuja occidentalis,* Tobin Harbor Coll by J L Lowe. This species is reported from Europe on *Pinus cembra* Det. by M L Lohman

*STICTIS CARESTIAE (De Not) Rehm. — On bark of *Thuja occi-*

dentalis, Rock Harbor Apparently this species has never been reported from this country or on this host, but a comparison with an authentic specimen (Rabenh Fung Eur No 775) leaves no doubt as to its identity Superficially the fungus resembles *S radiata* (L) Pers , but the smaller spores and the coniferous substratum deny this probability

STICTIS RADIATA (L) Pers — On *Acer spicatum* Lam , Siskowit Lake

PEZIZALES

DERMATEACEAE

CENANGIUM ABIETIS (Pers) Rehm — On *Abies balsamea*, Rock Harbor, largely the imperfect stage

CENANGIUM FURFURACEUM (Roth) De Not — On dead, but still standing, branches of *Alnus incana* (L) Moench in dense shade near the shore, Rock Harbor

*CENANGIUM POPULNEUM (Pers) Rehm — On decorticated twig of *Populus tremuloides*, Rock Harbor

*DERMATEA ALNI (Fkl) Rehm — On dead twig of living Alnus in old burned area, Siskowit Bay

DERMATEA CERASI (Pers) Fr (?) — On gall on *Prunus pennsylvanica* L., Lake Eva Trail from McCargoe Cove The absence of spores prevents an unquestionable determination

*GODRONIA URCEOLUS (A & S ex Fr) Karst — On dead stems of *Viburnum pauciflorum* Raf , Moose Lake, near Tobin Harbor Apparently this species has been reported in this country from Alaska only Moreover, this is a new host The smaller asci prevent this collection from being referred to *G Viburni* (Fkl) Rehm

*CORYNE VERSIFORMIS (Pers) Rehm — On rotten log in Sphagnum bog, Rock Harbor

*OMBROPHILA CLAVUS (A & S) Cke. — On submerged sticks and alder leaves in swamps, common, Rock Harbor, Tobin Harbor, and McCargoe Cove

MOLLISIACEAE

MOLLISIA CINEREA (Batsch) Karst. — On rotten log, Rock Harbor

*MOLLISIA RUFULA Sacc — On dead culms of *Calamagrostis sp* , Scoville Point and Rock Harbor

NIPTERA UDA (Pers) Fkl — On rotten wood in swamp, head of Tobin Harbor The spores in this collection are distinctly two-celled

*BELONIDIUM AURANTIACUM Rehm — On old, dead culms of *Calamagrostis sp* at the edge of a rock pool, Scoville Point

HELOTIACEAE

CHLOROSPLENIUM AERUGINASCENS (Nyl) Karst — On wood of frondose species, including *Populus tremuloides*, Angleworm Lake, Ryan Island in Siskowit Lake, and near the outlet of Siskowit Lake

CHLOROSPLENIUM AERUGINOSUM (Oeder) De Not — A single collection on a rotten stick, Rock Harbor

DASYSCYPHA AGASSIZII (B & C) Sacc — On *Abies balsamea*, Rock Harbor Det by G G Hahn

*DASYSCYPHA ARIDA (Phill) Sacc — On *Abies balsamea*, Rock Harbor Det by G G Hahn

*DASYSCYPHA CALYCIFORMIS (Willd) Rehm — On a canker on *Pinus Banksiana* Lamb , Mott Island Det by G G Hahn

*DASYSCYPHA DISTINGUENDA (Karst) Sacc — On rotten wood of frondose species, Rock Harbor

*DASYSCYPHELLA CASSANDRAE Tranzs (*Ennella borealis* Povah) — On dead stems of *Chamaedaphne calyculata* (L) Moench , in swamp of *Thuja occidentalis*, Rock Harbor Coll by A H Povah, No Fp 497 For a discussion of this synonymy see the paper by Kanouse in this volume, pp 74–75

HELOTIUM CITRINUM (Hedw) Fr — On poplar and other frondose species, Benson Lake and at the outlet of Siskowit Lake

*HELOTIUM LIMONICOLOR Bres — On *Thuja occidentalis*, Tobin Harbor

*HELOTIUM RHIZOPHILUM Karst — On rotten wood in swamp, Moose Lake

HELOTIUM VIRGULTORUM (Vahl) Karst var. FRUCTIGENUM (Bull) Rehm — On alder catkins in swamp, Passage Island

*LACHNELLA CORTICALIS (Pers) Fr — On bark of dead *Populus tremuloides*, Rock Harbor

*LACHNUM HYALINELLUM Rehm — On wood of *Thuja occidentalis* and on cone scales of *Picea canadensis*, Scoville Point and Rock Harbor

LACHNUM VIRGINEUM (Batsch) Karst — On poplar twigs in moist duff, Rock Harbor The crystals on the excipular hairs are soluble in potassium hydroxide solution, like those found in some of the Thelephoraceae

*PHIALEA SUBCARNEA (Cke & Pk) Sacc — Parasitic upon, and killing, *Dicranum flagellare* Hedw, leafy liverworts and mosses, Rock Harbor, Forbes Lake, and Hay Bay This interesting species was described by Peck from infected liverworts collected at Sand Lake, New York In the Farlow Herbarium it is represented by the following collections Shelburn, New Hampshire, and Lac Clair, Canada, Farlow, and N A Fungi No 2143, Adirondack Mountains, Rex All these are on moss Plate XXIII, Figure 2

*SCLEROTINIA BIFRONS Seaver — Parasitic upon leaves of *Populus tremuloides*, Rock Harbor and Sargent Lake

PEZIZACEAE

ACETABULA VULGARIS Fkl — On ground, Rock Harbor and at the outlet of Siskowit Lake

ALEURIA AURANTIA (Pers) Fkl — On soil, Rock Harbor

*ALEURIA WISCONSINENSIS Rehm — On decaying leaves, Rock Harbor

*DISCINA MACROSPORA Bubak — On rotten log, Smithwick Island This species is not given in Seaver (25)

*HUMARIA THELEBOLOIDES (A & S) Rehm — On moose dung, Rock Harbor, and on very wet soil, Passage Island

*LAMPROSPORA CARBONARIA (Fkl) Seaver — On soil, at the outlet of Chickenbone Lake The specimen has been compared with the cotype of *Barlaea carbonaria* (Fkl) Sacc in the Farlow Herbarium

LAMPROSPORA CREC'HQUERAULTII (Crouan) Boud (*Barlaea asperella* (Rehm) Sacc.) —On wet soil, at the head of Tobin Harbor, near Angleworm Lake, and at McCargoe Cove

*MACROPODIA CORIUM (Weberb) Sacc — On rotten wood, Mott Island

MACROPODIA MACROPUS (Pers) Fkl — On soil or rotten wood, McCargoe Cove, Rock Harbor, and Tobin Harbor

PEZIZA CLYPEATA Schw — On very wet conifer stump, above

beaver dam in the outlet of Mud Lake, at the west end of Siskowit Lake

PEZIZA VESICULOSA Bull (?) — On shady, mossy bank, head of Tobin Harbor

PLICARIA BADIA (Pers) Fkl — Common on rotten wood, Rock Harbor, Passage Island, Lake Eva, and Tobin Harbor

PLICARIA BRUNNEO-ATRA (Desm) Rehm — On soil, Lake Eva, and Tobin Harbor

PLICARIA FIMETI (Fkl) Rehm — On moose dung, Rock Harbor and Tobin Harbor

PLICARIA REPANDA (Wahlb) Rehm — Two collections from rotten wood, Tobin Harbor

PLICARIA RUBROFUSCA Rehm — Reported only by Rehm (24).

*PSEUDOPLECTANIA NIGRELLA (Pers) Fkl — A single collection on wood, Rock Harbor

PYRONEMA OMPHALODES (Bull) Fkl — On burned soil, Rock Harbor

*SCUTELLINIA COPRINARIA (Cke) Kuntze (*Lachnea coprinaria* (Cke) Phill) — On moose dung, Rock Harbor and at the outlet of Siskowit Lake

*SCUTELLINIA FUSICARPA (Ger) Kuntze (*Lachnea aspera* Sacc & Syd) — On ground in arbor vitae swamp, Rock Harbor

*SCUTELLINIA GREGARIA (Rehm) Kuntze (*Lachnea gregaria* (Rehm) Phill) — A single collection on rotten wood, McCargoe Cove

SCUTELLINIA HEMISPHERICA (Wigg) Kuntze (*Lachnea hemispherica* (Wigg) Gill) — Common on wet, rotten wood, Rock Harbor, Mott Island, and Sargent Lake.

***Scutellinia michiganensis* Povah, comb nov** (*Patella michiganensis* Povah) — On moose dung, Moose Lake near Tobin Harbor and Sargent Lake Trail from McCargoe Cove Coll by J L Lowe The Moose Lake collection (No Fp 211, coll by A H Povah) is the type from which the species was described (22)

SCUTELLINIA SCUTELLATA (L) Lamb (*Lachnea scutellata* (L.) Gill) — Common on wet, rotten wood and occasional on soil and moose dung, Rock Harbor and Tobin Harbor

SCUTELLINIA SETOSA (Nees) Kuntze (*Lachnea setosa* (Nees) Gill) — A single collection on wet, rotten wood, Tobin Harbor

Ascobolaceae

Ascobolus stercorarius (Bull.) Schröt. — On moose dung, Sargent Lake.

*Ascobolus vinosus Berk. — On moose dung, Rock Harbor. This collection cannot be referred to *A. stercorarius* (Seaver, p. 92). Asci 150–170 × 20–25 μ, spores 18–20 × 9 μ.

*Ascophanus argenteus (Crouan) Boud. — On moose dung near Sargent Lake.

Ascophanus carneus (Pers.) Boud. — On moose dung, mixed with *Lasiobolus longisetosus* Povah, at the outlet of Siskowit Lake.

Lasiobolus longisetosus Povah. — Abundant on moose dung, Rock Harbor, Mott Island, and at the outlet of Siskowit Lake.

Helvellaceae

Rhizinae

*Psilopeziza nummularia Berk. — On rotten wood, Chickenbone Lake.

Helvellae

Gyromitra infula (Pers.) Quél. — On ground in wet places, Lake Eva, McCargoe Cove, Wallace Lake, Siskowit Bay, and Passage Island.

*Helvella atra König. — On very wet soil, McCargoe Cove, Tobin Harbor, at the outlet of Siskowit Lake, and at the outlet of Chickenbone Lake.

Helvella elastica Fr. — On wet soil, Tobin Harbor and Siskowit Lake.

Helvella infula Schaeff. — All specimens collected are parasitized by *Sphaeronemella Helvellae* Karst., Wallace Lake.

Helvella lacunosa Afzel. — Four collections in moist woods, Tobin Harbor, Rock Harbor, and Birch Island in McCargoe Cove.

Geoglossae

*Apostemidium Guernisaci (Crouan) Boud. — Only two specimens on sticks in water, Monument Rock Trail. This species is apparently known hitherto only from the New England states and Wa

CUDONIA CIRCINANS (Pers) Fr — On ground rich in leafy débris, Tobin Harbor, Passage Island, and McCargoe Cove

GEOGLOSSUM GLABRUM Pers — Four collections, Tobin Harbor, McCargoe Cove, and north of Hay Bay

GEOGLOSSUM NIGRITUM Cke — A single collection, north of Hay Bay

LEOTIA STIPITATA (Bosc) Schröt — On rotten wood in arbor vitae swamp, Rock Harbor

MICROGLOSSUM RUFUM (Schw) Underw — Rather common on rotten wood, in wet places, Rock Harbor, Lake Eva, McCargoe Cove, and at the outlet of Siskowit Lake

*MITRULA IRREGULARIS (Pk) Dur — A single collection from mossy ground under conifers, Rock Harbor, and one from a swamp of arbor vitae, Rock Harbor

MITRULA PHALLOIDES (Bull) Chev — Abundant on decaying leaves in pools in swamps, Rock Harbor, Tobin Harbor, and Blake Point

SPATHULARIA CLAVATA (Schaeff) Sacc — Common on rotten wood (white birch) and on soil in mixed woods, Rock Harbor, Tobin Harbor, Greenstone Ridge, and Passage Island

TRICHOGLOSSUM HIRSUTUM (Pers) Boud — A single collection in a swamp at the head of Rock Harbor

VIBRISSEA TRUNCORUM (A & S) Fr — Two collections from sticks in running water, Monument Rock Trail from Tobin Harbor

AGYRIALES

EXASCACEAE

*TAPHRINA CERASI (Fkl) Sadebeck — Causing witches'-brooms on *Prunus pennsylvanica* L , Lake Eva Trail

TUBERALES

ONYGENACEAE

*ONYGENA CORVINA A & S — On decaying feathers of a sea gull, Bat Island Apparently the only published record of this fungus in North America occurs in Bisby, Buller and Dearness, *The Fungi of Manitoba* (1) Dr Thaxter informed the writer that he had collected this species on owl pellets at Kittery Point, Maine Plate XXIII, Figure 1

ELAPHOMYCETACEAE

*ELAPHOMYCES GRANULATUS Fr — On surface of soil under arbor vitae, Lake Ritchie

TUBERACEAE

*TUBER SEPARANS Gilkey (?) — One inch below the surface of the soil, at the outlet of Chickenbone Lake Dr Gilkey writes "Asci and spores are immature, but structural characters of cortex and hymenium are those of *T separans* Gilkey" This species was originally collected in California and has since been reported only once, from Winnipeg, Canada (1) Det by Helen M Gilkey

PROMYCETES

USTILAGINALES

USTILAGINACEAE

CINTRACTIA CARICIS (Pers) Magn — Rather widely distributed on *Carex trisperma* Dewey, *C stricta* Lam , *C paupercula* Michx , *C aurea* Nutt , *Scirpus subterminalis* Torr , and *S caespitosus* L , Rock Harbor, Passage Island, Moose Lake, Tobin Harbor, Lake Eva, and Sumner Lake

PUCCINIALES

PUCCINIACEAE

GYMNOSPORANGIUM CLAVIPES Cke & Pk — On *Amelanchier spicata* (Lam) C Koch , Sargent Lake Trail from McCargoe Cove

GYMNOSPORANGIUM JUNIPERI Lk — On *Sorbus americana*, Rock Harbor This rust is exceedingly common and gives to the landscape a brilliant touch of color in late summer

*PERIDERMIUM COLORADENSE (Diet) Arth & Kern — Causing witches'-brooms on *Picea canadensis*, near old mine, Rock Harbor, and on high ridge, McCargoe Cove, causing witches'-brooms on *Picea mariana*, Rock Harbor

PHRAGMIDIUM OCCIDENTALE Arth — On *Rubus parviflorus* Nutt , Rock Harbor and at the head of Tobin Harbor

PHRAGMIDIUM ROSAE-ACICULARIS Liro — On *Rosa acicularis* Lindl , Rock Harbor, Mott Island, at the outlet of Siskowit Lake, and in an old burned-over area, Siskowit Bay

Puccinia Asteris Duby — On *Aster macrophyllus* L, Rock Harbor

*Puccinia calthaecola Schröt — On *Caltha palustris* L, Passage Island

Puccinia Circaeae Pers — On *Circaea alpina* L, at the head of Rock Harbor Coll by C A Brown

Puccinia conglomerata (Strauss) Schmidt & Kunze — On *Petasites palmatus* (Ait) Gray, two collections, Rock Harbor, by C A Brown

Puccinia coronata Cda — On *Calamagrostis canadensis*, Passage Island and Rock Harbor, on *Rhamnus alnifolia* L'Hér, Rainbow Harbor and Washington Harbor Coll by C A Brown

*Puccinia Epilobii DC — On *Epilobium densum* Raf, Moose Lake, near Tobin Harbor Coll by C A Brown Mains writes "This species is apparently only rarely collected in North America It is reported only from Wyoming, Quebec, and Greenland This is, apparently, the first collection on *Epilobium densum*"

*Puccinia extensicola Plow — On *Aster sp*, Tobin Harbor and Moose Lake

Puccinia graminis Pers — On *Phleum pratense* L, Rock Harbor and Forbes Lake, on *Agropyron tenerum* Vasey, Rock Harbor

*Puccinia Grindeliae Pk — On *Solidago sp*, Mount Franklin

Puccinia HalenIae Arth & Holw — On *Halenia deflexa* (Sm) Griesb, Rock Harbor

*Puccinia Heucherae (S) Dietl — On *Mitella nuda* L, Rock Harbor, Mott Island, Lake Ritchie, and at the head of Tobin Harbor

Puccinia Hieracii (Schum) H Mart — On *Hieracium canadense* Michx, Rock Harbor and McCargoe Cove, on *Taraxacum officinale* Weber, in old burned area, Siskowit Bay, on *Hieracium umbellatum*, Rock Harbor

Puccinia Iridis (DC) Wallr — On *Iris versicolor*, Siskowit Bay Coll by C. A Brown

*Puccinia Limosae Magn — On *Lysimachia terrestris* (L) BSP, growing on sedge mat on the shore of Moose Lake, Tobin Harbor

Puccinia Linkii Klotzsche — On *Viburnum pauciflorum* Raf, Rock Harbor, at the head of Tobin Harbor, and Passage Island The rust affects the leaves, petioles and tender stems, oftentimes

causing marked distortions When fresh the fungus possesses a very disagreeable odor, which is thought to be attractive to insects, since flies were frequently observed crawling over the sori

PUCCINIA MENTHAE Pers — On *Satureja vulgaris* (L) Fritsch, Rock Harbor Coll by J B McFarlin, on *Mentha arvensis* var *canadensis* (L) Briq, at the west end of Siskowit Lake

PUCCINIA MESOMEGALA B & C — On *Clintonia borealis* (Ait) Raf, Rock Harbor Coll by C A Brown and J L Lowe

*PUCCINIA PERMINUTA Arth — On *Cinna latifolia* (Trev) Griesb, at the head of Tobin Harbor Mains writes "Probably best considered a race of *P rubigo-vera*"

PUCCINIA POARUM Niels — On *Poa sp*, in dry, rocky place along Sargent Lake Trail from McCargoe Cove

PUCCINIA PRINGSHEIMIANA Kleb — On *Ribes prostratum* L'Hér, Washington Island in Washington Harbor Coll by C A Brown

PUCCINIA PYGMAEA Erikss — On *Oryzopsis asperifolia* Michx, at the head of Tobin Harbor and Sargent Lake Coll by J B McFarlin and J L Lowe

*PUCCINIA PYROLAE Cke — On *Polygala paucifolia* Willd, McCargoe Cove, coll by C A Brown, and Lake Ritchie

PUCCINIA RUBIGO-VERA (DC) Wint — On *Thalictrum dasycarpum*, head of Tobin Harbor Coll by C A Brown

*PUCCINIA SESSILIS Schneid — On *Maianthemum canadense* Desf, in very wet place on Mott Island

PUCCINIA VIOLAE (Schum) DC — On *Viola renifolia* Gray, Mott Island, coll by C A Brown, on *Viola sp* in swamp, Rock Harbor, and on high rocky ridge, Forbes Lake

*PUCCINIA WALDSTEINIAE M A Curtis — On *Waldsteinia fragarioides* (Michx.) Trattinick, on Greenstone Ridge near Mount Ojibway (Sec 21, T 66 N, R 34 W)

*UROMYCES AMOENUS Syd — On *Anaphalis margaritacea* (L) B & H, Rock Harbor Mains writes "Previously reported only from northwestern United States and British Columbia"

UROMYCES FABAE (Pers) DeBy — On *Lathyrus ochroleucus* Hook, Mount Franklin (Sec 21, T 66 N, R. 34 W) Coll by J L Lowe

UROMYCES HYPERICI (Schw) Curt. — On *Hypericum virginicum* L, Moose Lake.

*Uromyces Jacksonii Arth & Fromme — On *Deschampsia sp*, Rock Harbor Mains writes "Previously reported only from the Pacific Coast"

Uromyces Trifolii (Hedw f) Lév — On *Trifolium repens* L, Rock Harbor

Melampsoraceae

Calyptospora Goeppertiana J Kühn — On *Vaccinium pennsylvanicum* Lam, at the head of Tobin Harbor

Chrysomyxa Cassandrae (Pk & Clint) Franzs — On *Chamaedaphne calyculata*, Rock Harbor

*Chrysomyxa Chiogenis Diet — On *Chiogenes hispidula* (L) Torr & Gr, Rock Harbor

Chrysomyxa ledicola Lagh — On *Picea mariana* (Mill) BSP, and on *Ledum groenlandicum*, Lake Eva, Rock Harbor, and Benson Lake

Chrysomyxa Pyrolae (DC) Rostr — On cones of *Picea canadensis*, island near McCargoe Cove (Sec 15, T 66 N, R 33 W), on *Pyrola secunda* L, Rock Harbor and Tobin Harbor, on *Pyrola chlorantha* Sw, Moose Lake, on *Moneses uniflora* (L) Gray, Rock Harbor

Coleosporium Solidaginis (Schw) Thüm — On *Aster macrophyllus* L, at the head of Tobin Harbor

Cronartium Commandrae Pk — On *Commandra pallida* A DC, Benson Lake, and on *Commandra livida* Richards, Lake Ritchie Trail

Hyalopsora Aspidiotus (Pk) Magn — On *Phegopteris dryopteris* (L) Fee, Rock Harbor

Melampsora Humboldtiana Speg — On *Salix sp*, Rock Harbor and Benson Lake

*Melampsora Populi-Tsugae J J Davis — On *Populus tremuloides*, Rock Harbor and in old burned area, Siskowit Bay

Melampsorella Caryophyllacearum Schröt — On *Abies balsamea*, Rock Harbor and Mott Island, on *Stellaria sp*, Passage Island

*Melampsoridum betulinum (Tul) Kleb — On seedlings of *Betula alba* var *papyrifera*, McCargoe Cove

Pucciniastrum Epilobii Otth — On *Epilobium adenocaulon* Haussk, Sargent Lake Trail, and at the head of McCargoe

Cove, on *E angustifolium* L, in old burned area, Siskowit Bay

*PUCCINIASTRUM POTENTILLAE Kom — On *Potentilla tridentata* Ait, two collections, rock crevices near water's edge, Rock Harbor

BASIDIOMYCETES

TREMELLALES

AURICULARIACEAE

AURICULARIA AURICULA-JUDAE (L) Schröt — On coniferous wood and on bark of mountain maple, Smithwick Island, Tobin Harbor, and at the outlet of Siskowit Lake

TREMELLACEAE

EXIDIA GLANDULOSA (Bull) ex Fr — On alder and white birch, Tobin Harbor and Smithwick Island Rather common

GYROCEPHALUS RUFUS (Jacq) Bref — On coniferous wood, McCargoe Cove and at the outlet of Chickenbone Lake

*TREMELLA ENCEPHALA Willd — On twig of balsam fir, Ryan Island in Siskowit Lake

TREMELLA MESENTERICA Retz — On alder, Moose Lake, McCargoe Cove, and Tobin Harbor

TREMELLODON GELATINOSUM (Scop) Pers — On coniferous logs, Moose Lake and Passage Island

*SEBACINA CALCEA (Pers) Bres — On *Picea sp*, Moose Lake

DACRYOMYCETACEAE

CALOCERA PALMATA (Schw) Fr — On log of frondose species, at the head of Tobin Harbor

DACRYOMYCES DELIQUESCENS (Bull) Duby — On alder and *Thuja occidentalis*, at the head of Tobin Harbor, Smithwick Island, Scoville Point, and at the west end of Siskowit Lake Common

*DACRYOMYCES PALMATUS (Schw) Burt — On coniferous wood, especially spruce, Monument Rock Trail, Moose Lake, Ryan Island in Siskowit Lake, and at the west end of Siskowit Lake Common

AGARICALES

THELEPHORACEAE

ALEURODISCUS AMORPHUS (Pers) Rabh — On *Abies balsamea*, Rock Harbor, and at the outlet of Siskowit Lake

*ALEURODISCUS NIVOSUS (B & C) v H & Litsch — On *Thuja occidentalis*, Rock Harbor, Tobin Harbor, and McCargoe Cove This is, apparently, a new host Burt (3) reports it on two species of Juniperus and Chamaecyparis

*CONIOPHORA BYSSOIDEA (Pers) Fr — On coniferous log, old Polystictus, and on débris of forest floor, Tobin Harbor and Moose Lake

*CORTICIUM CALCEUM Fr emend Burt — On *Thuja occidentalis*, at the outlet of Siskowit Lake

CORTICIUM LAETUM (Karst) Bres — Collected only by Stuntz and Allen (4)

CORTICIUM LIVIDO-CAERULEUM Karst — On under side of coniferous log, a single collection, Tobin Harbor This specimen has been compared with the type in the Von Höhnel Herbarium in the Farlow Herbarium In the former herbarium is another collection of interest, E T Harper and S A Harper No 985 It is this same species, collected in 1904 at Rock Harbor, Isle Royale It was determined by Bresadola and on the packet the spores are given as 7–11 × 3–4 5 μ

*CORTICIUM LIVIDUM Pers — On log of *Picea canadensis*, Monument Rock Trail from Tobin Harbor

*CORTICIUM VESICULOSUM Burt (?) — On under side of coniferous log, Tobin Harbor The specimen is referred to this species although growing on a coniferous substratum No gloeocystidia were found, but vesicular bodies are present Since no authentic specimen was available for comparison, the identification is marked "uncertain"

*CYPHELLA FASCICULATA Schw ex B & C — On branch of frondose species, Rock Harbor

CYPHELLA TILIAE Pk ex Cke. — On twigs of *Thuja occidentalis*, McCargoe Cove

CYTIDIA SALICINA (Fr) Burt — On alder and willow, Rock Harbor and Siskowit Lake

EXOBASIDIUM VACCINI (Fkl) Woronin — On *Chamaedaphne calyculata*, Rock Harbor, and on *Vaccinium pennsylvanicum*, Tobin Harbor Det by E B Mains

HYMENOCHAETE AGGLUTINANS Ellis — On living *Alnus incana*, at the outlet of Siskowit Lake

HYMENOCHAETE CORRUGATA (Fr) Lév — On *Picea canadensis* and *Thuja occidentalis*, at the outlet of Siskowit Lake and at Tobin Harbor, also by Allen and Stunts (4)

HYMENOCHAETE TABACINA (Sowerb) Lév — Common On spruce, white birch, alder, and *Thuja occidentalis*, Smithwick Island, Rock Harbor, Mott Island, McCargoe Cove, and at the outlet of Siskowit Lake also by Allen and Stunts (4)

*HYMENOCHAETE TENUIS Pk — On *Thuja occidentalis*, at the outlet of Siskowit Lake

HYPOCHNUS CERVINUS Burt — On moose dung, Rock Harbor

*HYPOCHNUS PALLIDOFULVUS (Pk) Burt — On *Peltigera sp* and on old alder, Passage Island and McCargoe Cove

HYPOCHNUS PANNOSUS (B & C) Burt — On log of frondose species, Tobin Harbor

HYPOCHNUS RUBIGINOSUS Bres — On arbor vitae, McCargoe Cove

PENIOPHORA AURANTIACA Bres — On *Alnus incana*, Rock Harbor, Moose Lake, and at the head of Rock Harbor

PENIOPHORA CINEREA (Pers) Cke — On alder and white birch, Rock Harbor and Smithwick Island

*PENIOPHORA FILAMENTOSA (B & C) Burt — On white birch log, McCargoe Cove

PENIOPHORA GIGANTEA (Fr) Mass — On *Alnus sp*, at the outlet of Siskowit Lake

*PENIOPHORA GLEBULOSA Bres — On dead twigs of *Abies balsamea*, Rock Harbor

PENIOPHORA INCARNATA (Pers) Bres — On *Populus tremuloides*, Rock Harbor

*PENIOPHORA POPULNEA (Pk) Burt — On *Populus tremuloides*, Rock Harbor and Mount Franklin

SOLENIA ANOMALA (Pers) Fkl — On white birch log, Tobin Harbor

STEREUM ABIETINUM Pers — On balsam fir log, McCargoe Cove

Schw — Collected only by Allen and Stunts

HIRSUTUM Willd ex Fr — Common on white birch,

Smithwick Island, at the outlet of Siskowit Lake, Tobin Harbor, and McCargoe Cove

STEREUM MURRAYI (B & C) Burt — On white birch, Tobin Harbor, on *Betula lutea*, north of Siskowit Lake, and on frondose species, McCargoe Cove

STEREUM PURPUREUM Pers — Common on white birch and quaking aspen, Moose Lake, Tobin Harbor, McCargoe Cove, at the outlet of Siskowit Lake, and at the head of Tobin Harbor

STEREUM RUFUM Fr — On *Populus tremuloides*, Mount Franklin, Tobin Harbor, and Rock Harbor

*STEREUM SANGUINOLENTUM A & S — On dead *Abies balsamea*, Passage Island and Tobin Harbor

THELEPHORA ANTHOCEPHALA (Bull) Fr — On ground under conifers, McCargoe Cove

THELEPHORA MULTIPARTITA Schw — On ground in mixed woods near the water's edge, at the head of Tobin Harbor

*THELEPHORA SCISSILIS Burt — On ground, at the outlet of Chickenbone Lake Although known only from the type collected in Washington, the specimen is referred to this species after having been compared with the type Plate XXII, Figure 1

*THELEPHORA SPICULOSA Fr — Growing on leaves and slightly ascending stems, at the outlet of Chickenbone Lake

*CLAVARIA APPALACHIENSIS Coker — In arbor vitae swamp, north of Hay Bay

CLAVARIA CINEREA Bull — On ground, Angleworm Lake, in mixed woods, Sargent Lake The plant is white, with a purplish tinge when fresh, with the tips almost white, but darkens in age The spores in our specimens measure 7 7–10 × 7 μ

CLAVARIA CRISTATA (Holmsk) Pers — In white birch forest, Sargent Lake, and near the outlet of Chickenbone Lake

CLAVARIA INAEQUALIS Müll — In arbor vitae swamp, Lake Ritchie, in swamps, Rock Harbor, at the outlet of Chickenbone Lake, and Siskowit Lake

CLAVARIA LIGULA Schaeff — On coniferous duff and in arbor vitae swamp, McCargoe Cove, at the outlet of Chickenbone Lake, and at the outlet of Siskowit Lake

*CLAVARIA OBTUSISSIMA Pk — In mixed woods, north of Siskowit

Lake, Rock Harbor, Lake Ritchie, and McCargoe Cove The last-mentioned collection has the following field notes "Plant cadmium yellow (R) when young, changing to deep chrome (R) when mature, whitish at the base, tips concolorous with the branches, flesh white or pinkish, not changing color when bruised, brittle, taste mild, odor slightly disagreeable, spores pale ochraceous, 9–10 5 × 3 5–4 5 μ smooth"

CLAVARIA PISTILLARIS L — Three collections, Rock Harbor, Siskowit Bay, and at the head of Rock Harbor

CLAVARIA PULCHRA Pk — In arbor vitae swamp, Lake Ritchie, and on Ryan Island in Siskowit Lake

*CLAVARIA STRICTA Pers — On wood, Rock Harbor The material agrees with a specimen in the Farlow Herbarium, collected near Ithaca, New York, by Kauffman

LACHNOCLADIUM SP (?) — On sticks and on moose dung Immature At the outlet of Chickenbone Lake

HYDNACEAE

*HYDNUM ALBIDUM Pk — In arbor vitae swamp, McCargoe Cove, and in mixed woods, Passage Island

HYDNUM ALBO-NIGRUM Pk — On low, wet ground, Chickenbone Lake

*HYDNUM ALBOVIRIDE Morg — On under side of *Thuja occidentalis*, at the outlet of Siskowit Lake

HYDNUM AURANTIACUM Fr — On ground under conifers, Sargent Lake

*HYDNUM CASEAREUM Morg — On under side of rotten log of frondose species (poplar ?), Tobin Harbor The collection agrees with a specimen in the Farlow Herbarium, collected and determined by J R Weir The spores are globose, hyaline, and measure 4–5 μ

HYDNUM CYANEOTINCTUM Pk — On soil in mixed woods, McCargoe Cove

HYDNUM ERINACEUS (Bull) Fr — On *Populus tremuloides*, Sumner Lake

*HYDNUM FARINACEUM Pers (?) — On bark of *Pinus Strobus*, McCargoe Cove

HYDNUM IMBRICATUM (L) Fr — On ground, Bailey's Island, in Tobin Harbor, head of Tobin Harbor, and on Passage Island

*HYDNUM LACINIATUM Leers — On white birch log, Birch Island, McCargoe Cove

HYDNUM OCHRACEUM Fr — On white birch and alder, Tobin Harbor and Rock Harbor

HYDNUM ZONATUM Batsch — On soil in balsam fir woods, Tobin Harbor and Moose Lake

ODONTIA FIMBRIATA Pers ex Fr — On wood of frondose species, including quaking aspen, Rock Harbor and Chickenbone Lake

*ODONTIA PRUNI Lasch — On *Prunus pennsylvanica*, north of Siskowit Lake

ODONTIA RIMOSISSIMA Pk — On alder and white birch, Rock Harbor and Smithwick Island

ODONTIA VESICULOSA Burt ined — On white birch, Rock Harbor A fragment of the type in the Farlow Herbarium shows that Burt named this species from material collected by the writer at Vermilion, Michigan (cf Povah, 20, p 262)

PHLEBIA PILEATA Pk — On poplar, felled by beaver, near dam, Siskowit Lake

*RADULUM ORBICULARE Fr — On alder and white birch, Hidden Lake, Tobin Harbor, and Duncan Bay

POLYPORACEAE

BOLETINUS PICTUS Pk — Three collections in mixed and coniferous woods, McCargoe Cove and Tobin Harbor

BOLETUS SCABER Fr — Rock Harbor

*BOLETUS SCABER Fr var AURANTIACA Pk — Under conifers, Rock Harbor

BOLETUS SUBGLABRIPES Pk — Under conifers, Sargent Lake

BOLETUS SUBTOMENTOSUS L — In low, wet, mixed woods, Hidden Lake.

DAEDALEA UNICOLOR (Bull) Fr — On poplar and mountain ash, McCargoe Cove and Siskowit Lake

FOMES APPLANATUS Gill — On white birch, Tobin Harbor

FOMES CONCHATUS (Pers ex Fr) Karst — On dead *Fraxinus nigra* in swamp, at the head of McCargoe Cove An interesting collection because the specimens are pileate

FOMES CONNATUS (Weinm) Gill — On *Acer rubrum* L, Mount Ojibway, and on living *A saccharum* Marsh, north of Hay Bay

FOMES FOMENTARIUS (Fr) Gill — On white birch, Tobin Harbor.

FOMES IGNIARIUS (L ex Fr) Gill — Parasitic on *Populus loides*, Rock Harbor, Hidden Lake, and Tobin Harbor, parasitic upon *Ostrya virginica*, north of Hay Bay, on dead alder, Siskowit Lake and Rock Harbor

FOMES NIGRICANS Fr ex Gill — Parasitic upon white birch, north of Siskowit Lake, north of Hay Bay, and on Smithwick Island, on rotten log, Moose Lake, on *Betula lutea*, north of Siskowit Lake

*FOMES PINI Brot ex Fr Karst — On stump of *Pinus Strobus*, Lake Eva

FOMES PINICOLA (Schw) Cke — Common on various conifers, Rock Harbor, Tobin Harbor, McCargoe Cove, and Siskowit Bay, on white birch, Tobin Harbor and Siskowit Lake, on *Populus tremuloides*, Tobin Harbor

FOMES ROSEUS (A & S) Cke — Rather common on coniferous logs, Tobin Harbor and Siskowit Lake

FOMES SCUTELLATUS (Schw) Cke — Infrequent on alder, Hay Bay, Lake Ritchie, and at the outlet of Chickenbone Lake

LENZITES BETULINA (L) ex Fr — Infrequent on white birch, Todd Harbor

LENZITES SEPIARIA (Wulf) Fr — Rather frequent on coniferous logs, Tobin Harbor and Rock Harbor, on willow, Tobin Harbor

MERULIUS BELLUS B & C — On coniferous log, Rock Harbor

MERULIUS GYROSUS Burt — On under side of frondose log, Tobin Harbor, and on under side of birch log, McCargoe Cove This is apparently the first collection since the type was found In the present specimens the spores, measuring 5-7 × 1-1 5 μ, are slightly longer than those in the type collection

MERULIUS NIVEUS Fr — On alder, McCargoe Cove Collected also by Allen and Stuntz (3)

POLYPORUS ADUSTUS (Willd) ex Fr — On poplar and white birch, Chickenbone Lake, Angleworm Lake, and Duncan Bay

POLYPORUS ALBELLUS Pk — On white birch, Rock Harbor, on alder, Tobin Harbor and Rock Harbor, on *Betula lutea*, Siskowit Lake, on mountain ash, Siskowit Lake

POLYPORUS ALBOLUTEUS E & E — A single collection of *Picea canadensis*, Tobin Harbor This, with tubes measuring 7-17 mm in length, is more like the western specimens

POLYPORUS ALUTACEUS Fr (*P guttulatus* Pk) — Common on co-

niferous wood, especially spruce and balsam fir, Tobin Harbor, McCargoe Cove, Sargent Lake, Chickenbone Lake, north of Siskowit Lake, and at the outlet of Siskowit Lake

POLYPORUS BALSAMEUS Pk — On root of *Abies balsamea*, at the outlet of Siskowit Lake

POLYPORUS BENZOINUS Wahl ex Fr — On coniferous log, Big Island (in Tobin Harbor) and Chickenbone Lake

POLYPORUS BETULINUS Bull ex Fr — Common on birch, Tobin Harbor and Siskowit Lake

POLYPORUS BOREALIS Fr — On stump of *Picea canadensis*, Wallace Lake

POLYPORUS BRUMALIS Pers ex Fr — On alder and other frondose species, Moose Lake and north of Hay Bay

POLYPORUS CHIONEUS Fr — On alder and white birch, Rock Harbor, Tobin Harbor, and McCargoe Cove

*POLYPORUS CIRCINATUS Fr — Rather common on ground in coniferous woods, Rock Harbor, Tobin Harbor, Moose Lake, Wallace Lake, at the head of Tobin Harbor, and Forbes Lake

*POLYPORUS CONFLUENS Fr — A single collection from soil under conifers, Tobin Harbor Coll by J L Lowe and C A Brown Kauffman collected this species in Colorado (16) and Tennessee Det by J L Lowe

POLYPORUS DICHROUS Fr — On rotten log, at the head of Tobin Harbor

POLYPORUS DISTORTUS Schw ex Fr — On soil in mixed woods, McCargoe Cove

POLYPORUS DRYOPHILUS Berk. — On *Prunus pennsylvanica*, Lake Eva Trail, McCargoe Cove The specimens are smaller than usual, since they measure 2 5–6 cm broad, but they show the characteristic woody, central core The host is apparently unreported for this country, although Bourdot and Galzin (2) record Prunus for France

POLYPORUS ELEGANS Bull ex Fr. — Common on birch, alder, and willow, Rock Harbor, Tobin Harbor, and McCargoe Cove

POLYPORUS FIBRILLOSUS Karst — On very rotten balsam fir and on white birch Overholts (19) says that it grows on wood of coniferous trees In Europe it is found on poplar as well. This is apparently the first record on birch.

POLYPORUS FRAGILIS Fr — Causing a heart rot of *Abies* |

Duncan Bay Coll by C A Brown It is interesting to note in Fries (12, p 546) "Ad ligna abiegna carie consumta" This is apparently a new host, Seymour (26) gives *A grandis* Lindl and Saccardo gives *A pectinata* DC The Isle Royale specimens resemble very closely specimens collected by Farlow in Chocorua, New Hampshire (1917), and determined by J R Weir

POLYPORUS HIRTUS Quél — Common on conifers, usually on the roots On *Abies balsamea*, Passage Island, Chickenbone Lake, and McCargoe Cove, on *Picea canadensis*, Ryan Island in Siskowit Lake and Chickenbone Lake The species is usually considered rare both in Europe and in the United States It is easily distinguished by its large fusiform spores Kauffman (14) reported it from Isle Royale as *Polyporus hispidellus* Pk Plate XXIV

POLYPORUS LACTEUS Fr — On alder, Siskowit Lake, on balsam fir, McCargoe Cove

*POLYPORUS MOLLIS (Pers) Fr — On spruce, two collections, Tobin Harbor, coll by A H Povah, McCargoe Cove, coll by J L Lowe, on conifer log, Tobin Harbor, on ground under conifers, head of Rock Harbor, coll J B McFarlin Overholts writes "While your collections indicate that the species is not uncommon in the region where these were collected, yet in general it must be a rather uncommon plant Very few collections have ever reached me" The species was reported by the writer (21) from Rock River A reëxamination, however, of this specimen shows that it is not of this species The present Isle Royale material becomes, therefore, the first Michigan collection Det by L O Overholts

POLYPORUS PARGAMENUS Fr — Rather infrequent, on poplar and white birch, Tobin Harbor, Wallace Lake, and Ryan Island in Siskowit Lake

POLYPORUS PICIPES Fr — Rather common on coniferous wood, Rock Harbor, Tobin Harbor, and Moose Lake

POLYPORUS RADIATUS Sowerb. ex Fr — On alder, Rock Harbor, and on white birch, at the outlet of Chickenbone Lake To the writer the spores appear pale brown under the microscope, although both Lloyd and Overholts say that they are hyaline

POLYPORUS RESINOSUS Schrad ex Fr — On birch, north of Siskowit Lake and north of Hay Bay

POLYPORUS SCHWEINITZII Fr — On living and dead *Picea canadensis*, at the outlet of Chickenbone Lake, McCargoe Cove, and Lake Ritchie, on white pine stub, Lake Eva

*POLYPORUS (LEPTOPORUS) TRABEUS Rost *sensu* Bresadola — On coniferous log, north of Hay Bay Det by D V Baxter

POLYPORUS URSINUS Lloyd — On coniferous wood, especially spruce, Hay Bay, Tobin Harbor, at the outlet of Mud Lake, and at the west end of Siskowit Lake

POLYSTICTUS ABIETINUS (Dicks ex Fr) Cke — On coniferous wood, including spruce, Rock Harbor, Tobin Harbor, and at the outlet of Siskowit Lake

POLYSTICTUS CONCHIFER (Schw) Sacc — On white birch twig, Siskowit Bay This host is not given in Seymour (26)

POLYSTICTUS HIRSUTUS (Schrad) ex Fr — On alder and willow, Tobin Harbor and Rock Harbor

POLYSTICTUS PERENNIS (L ex Fr) Karst — On ground, Tobin Harbor, Angleworm Lake, and Rock Harbor

POLYSTICTUS PUBESCENS (Schum ex Fr) Lloyd — On alder and birch, Siskowit Lake and Forbes Lake

POLYSTICTUS VELUTINUS (Pers) ex Fr — On poplar, birch, and alder, Tobin Harbor, Rock Harbor, and Moose Lake

PORIA ATTENUATA (Pk) Cke — On rotten log, Rock Harbor

PORIA CARBONARIA B & C (*Fuscoporia carbonaria* (B & C) Murr , *Trametes Sequoiae* Copeland) — On charred wood of white pine, at the outlet of Chickenbone Lake

PORIA CRUSTULINA Bres — On spruce, Rock Harbor, at the head of Tobin Harbor Baxter writes "I have compared this with the type specimen My herbarium contains several collections of this plant from different sections of the United States It is common in certain sections of the Rocky Mountains and in the Yukon, as well as in parts of northeastern North America I plan to discuss this poria in a paper to appear in a future volume of this publication "

PORIA FERREA Pers — On hardwood limb on ground, Rock Harbor Baxter writes "This plant is exactly similar to the one of *Poria ferrea* which I have received from Romell "

*PORIA FERRUGINEO-FUSCA Karst , (*P marginella* (Pk) Sacc) — On old spruce log, Tobin Harbor

PORIA FERRUGINOSA (Schrad) Fr — On *Thuja occidentalis* and

Acer saccharum, at the outlet of Siskowit Lake and Greenstone Ridge, north of Hay Bay

*PORIA FIMBRIATELLA (Pk) Sacc — On coniferous log, Siskowit Bay

PORIA LENIS Karst — On coniferous log in old burn, Siskowit Bay

PORIA RUFA (Schrad) Fr — On under side of spruce log, Rock Harbor

PORIA SUBACIDA (Pk) Sacc — On spruce and white birch log, Rock Harbor, McCargoe Cove, and at the outlet of Siskowit Lake

*PORIA SUBICULOSA (Pk) Cke — On conifer log, Moose Lake

*PTYCHOGASTER CITRINUS *sensu* Romell — On under side of poplar (?) log, Monument Rock Trail from Tobin Harbor Baxter writes "This plant is closely allied to *Polyporus sericeomollis*, which is found on conifers The older and more mature specimens in the collection do not show this so well as do the other portions of the collection The 'cottony' mycelium in the badly decayed wood is very characteristic of this group of plants, which belongs to the series named *Polyporus vaillantii*, 'der Hausschwamm,' in Metz This collection from Isle Royale shows both basidiospores and abundant subglobose and variable chlamydospores The basidiospores of *P citrinus* are only very slightly larger than those of *Polyporus sericeo-mollis*" Det by D V Baxter

TRAMETES CINNABARINA Fr — On white birch and other frondose species, Moose Lake and Tobin Harbor

TRAMETES PINI Thore ex Fr — On spruce, fairly common, Rock Harbor and Tobin Harbor

TRAMETES QUERCINA Lloyd (*Polyporus arcticus* Fr) — On white birch, Siskowit Bay Two specimens in the Farlow Herbarium (ex Herb Ellis), collected in Colorado by Demetrio in 1888, are the same plant Since the name *Trametes articus* Berk is a synonym for *Fomes Palliseri* Berk , Lloyd's name is used because the plant is a Trametes rather than a Polyporus

TRAMETES SEPIUM Berk — On under side of decorticated balsam (?) log, McCargoe Cove Det by D V Baxter

TRAMETES SUBROSEA Weir — On living and dead *Picea canadensis*, Rock Harbor, Hay Bay, Tobin Harbor, and at the outlet of Siskowit Lake

TRAMETES TENUIS Karst — On various conifers, including *Thuja occidentalis* and *Pinus Strobus*, McCargoe Cove, Siskowit Lake,

Forbes Lake, Rock Harbor, and at the west end of Siskowit Lake Det by D V Baxter

TRAMETES VARIIFORMIS Pk — On under side of *Picea canadensis* log, Tobin Harbor

TRAMETES VARIIFORMIS Pk var INTERRUPTUS Pk — On conifer log, Tobin Harbor

TRAMETES VARIIFORMIS Pk var NODULOSUS Pk — On spruce log, Siskowit Lake, on conifer log, Tobin Harbor

TRAMETES VARIIFORMIS Pk var RESUPINATUS Pk — On under side of log of *Picea canadensis*, Rock Harbor

AGARICACEAE

AMANITA FLAVOCONIA Atk — Under conifers, at the outlet of Chickenbone Lake

*AMANITA HYGROSCOPICA Coker — Under spruces, Tobin Harbor Det by A H Smith

AMANITA MUSCARIA Fr — Under arbor vitae, Sargent Lake Det by A H Smith.

AMANITA TOMENTELLA Kromb — In mixed woods, Siskowit Lake, also reported by Kauffman (15)

AMANITOPSIS VAGINATA Fr var LIVIDA Pk — Rock Harbor

ARMILLARIA MELLEA (Vahl) Fr — On spruce root, north of Hay Bay

CANTHARELLUS CIBARIUS Fr — Tobin Harbor, Sargent Lake, and McCargoe Cove, also reported by Kauffman (15)

*CANTHARELLUS CLAVATUS Fr — In mixed woods, Tobin Harbor and McCargoe Cove

CANTHARELLUS INFUNDIBULIFORMIS Fr. — Under arbor vitae, Sargent Lake

*CANTHARELLUS MULTIPLEX Underw — On conifer stump, north of Hay Bay

CLITOCYBE INFUNDIBULIFORMIS Fr — Under conifers, Moose Lake and McCargoe Cove, also reported by Kauffman (15)

CLITOCYBE LACCATA Fr var AMETHYSTINA Bolt — In mixed woods, Rock Harbor and Tobin Harbor

CLITOCYBE OCHROPURPUREA Berk — Reported only by Kauffman (15)

COLLYBIA CONFLUENS Fr — Under birch trees and arbor vitae, Sargent Lake and Siskowit Lake

Collybia dryophila Bull — In mixed woods, Rock Harbor and Moose Lake

Collybia familia Pk (?) — On rotten log, Ryan Island in Siskowit Lake

Collybia maculata A & S — Reported only by Kauffman (15)

Cortinarius armillatus Fr — Under conifers, McCargoe Cove, also reported by Kauffman (15)

Cortinarius fulmineus Fr var sulphureus Kauff — Siskowit Bay

Cortinarius mammosus Kauff — In mixed woods, Rock Harbor

*Cortinarius Morrisii Pk — In wet woods, Rock Harbor

Cortinarius mucifluus Fr — In low, wet woods, Rock Harbor

Cortinarius sanguineus Fr — Reported only by Kauffman (15)

Cortinarius sphagnophilus Pk — In Sphagnum bog, Rock Harbor

Cortinarius violaceus Fr — Lake Eva, near Angleworm Lake, and Passage Island, also reported by Kauffman (15)

Crepidotus fulvotomentosus Pk — On poplar, Mott Island, Rock Harbor, and near old lighthouse

Hygrophorus conicus Fr — Infrequent in wet woods, McCargoe Cove

Hygrophorus miniatus Fr — Tobin Harbor

Hygrophorus nitidus B & C — Sargent Lake

Hygrophorus Peckii Atk — In mixed woods, McCargoe Cove, also reported by Kauffman (15)

Hypholoma perplexum Pk — Tobin Harbor

Inocybe calamistrata Fr — Under balsam firs, head of Tobin Harbor

Inocybe leptophylla Atk — In Sphagnum bog, Rock Harbor

Lactarius cinereus Pk — Reported only by Kauffman (15)

Lactarius deceptivus Pk — Reported only by Kauffman (15)

Lactarius deliciosus Fr — In alder, arbor vitae swamp, McCargoe Cove, also reported by Kauffman (15)

Lactarius rufus Fr — In swamp, Rock Harbor

Lactarius scrobiculatus Fr — Under conifers, Sargent Lake

Lactarius torminosus Fr — Under conifers, Rock Harbor, also reported by Kauffman (15)

Lactarius trivialis Fr — Reported only by Kauffman (15)

LACTARIUS TRIVIALIS Fr var VIRIDILACTIS Kauff — Under conifers, Lake Eva

LACTARIUS VELLEREUS Fr — On ground under conifers, Lake Eva

LENTINUS LEPIDEUS Fr — On coniferous log, Tobin Harbor

MARASMIUS ANDROSACEUS Fr — On balsam fir needles and birch leaves, Moose Lake and Ryan Island in Siskowit Lake

*MARASMIUS CAUTICINALIS Fr (*M tomentosipes* Pk) — On conifer needles, Tobin Harbor

MARASMIUS FOETIDUS Fr — On decaying conifer needles, McCargoe Cove

*MARASMIUS PERFORANS (Hoffm) Fr — On needles of *Picea sp*, Bat Island

MARASMIUS ROTULA (Scop) Fr — On rotten stick, at the outlet of Chickenbone Lake

MYCENA HAEMATOPODA Fr — On much-decayed, white birch stick, Rock Harbor

MYCENA LEAIANA Berk — On alder and poplar logs, Rock Harbor, and at the head of Tobin Harbor

NYCTALIS ASTEROPHORA Fr — On old agaric (*Russula sp* ?), at the outlet of Chickenbone Lake

OMPHALIA CAMPANELLA Fr — On conifer, Rock Harbor and Tobin Harbor, also reported by Kauffman (15)

*OMPHALIA SUBCLAVATA Pk — On rotten log, Rock Harbor

PANEOLUS RETIRUGIS Fr — On moose dung, at the outlet of Siskowit Lake

PANUS RUDIS Fr — On white birch log, McCargoe Cove

PAXILLUS ATROTOMENTOSUS Fr (?) — Siskowit Bay A single specimen was collected and referred to this species although the stem is scarcely tomentose, the spores agree

PAXILLUS INVOLUTUS Fr — Reported only by Kauffman (15)

PAXILLUS PANNOIDES Fr — On log of *Picea canadensis*, Chickenbone Lake

PHOLIOTA ALBOCRENULATA Pk — On living white birch tree, Tobin Harbor

PHOLIOTA CAPERATA Fr — Under conifers, at the head of Tobin Harbor

PHOLIOTA SQUARROSA Fr — On base of white birch, Siskowit Lake Det by A H Smith

PHOLIOTA SQUARROSOIDES Pk — On white birch, Siskowit Lake

PLEUROTUS APPLICATUS Batsch — On dead alder, Rock Harbor

PLEUROTUS OSTREATUS (Jacq) Fr — Rather common on birch and mountain ash, Rock Harbor and Passage Island

PLICATURA FAGINEA (Schrad) Karst — On dead alder, Benson Lake

PLUTEUS CERVINUS Fr — On rotten logs, Tobin Harbor and Moose Lake

PLUTEUS UMBROSUS Fr — On rotten log in swamp, McCargoe Cove

PSALIOTA ABRUPTIBULBA Pk — In mixed woods, Sargent Lake

RUSSULA AERUGINEA Fr — Under conifers, Rock Harbor and Lake Eva

RUSSULA AMYGDALOIDES Kauff — In mixed woods, Tobin Harbor

RUSSULA DECOLORANS Fr — Under spruces, Moose Lake and Tobin Harbor

RUSSULA EMETICA Fr — In Sphagnum bog, Rock Harbor

RUSSULA FLAVA Romell — In coniferous woods, Rock Harbor

RUSSULA SORDIDA Pk — In dense, mixed woods, at the head of Tobin Harbor

RUSSULA UNCIALIS Pk — In mixed woods, Rock Harbor

SCHIZOPHYLLUM COMMUNE Fr — On white birch log, Rock Harbor

STROPHARIA UMBONATESCENS Pk — On moose dung in swamp, Siskowit Lake

TRICHOLOMA RUTILANS Fr — In bog, under conifers, Rock Harbor, also reported by Kauffman (15)

LYCOPERDALES

RHIZOPOGONACEAE

*ALPOVA CINNAMOMEUS C W Dodge — Half buried in the soil in mixed woods Tobin Harbor, two collections by C A Brown, including Fp 73 type, Rock Harbor — trail from Post Office to dock — two collections, one by A H Povah and J L Lowe, and one by C A Brown, beside stream forming outlet of Siskowit Lake, collected by A H Povah The genus and species were described from these collections by Dodge (8)

LYCOPERDACEAE

BOVISTA PILA B & C — A single collection from grassy place, Amygdaloid Island

Bovistella pedicellata Pk — A single collection on soil, Rock Harbor

*Bovistella radicata (Mont) Pat — A single collection, McCargoe Cove

Geaster coronatus (Schaeff) Schröt — Two collections from dry, rocky, grassy places, McCargoe Cove and Mount Franklin

Lycoperdum atropurpureum Vitt — On rotten log and on ground, Rock Harbor, Tobin Harbor, and north of Hay Bay

*Lycoperdum fuscum Bonord — On soil and on wood, Passage Island

Lycoperdum gemmatum Batsch — On rotten wood and on soil, Sargent Lake, Ryan Island in Siskowit Lake, McCargoe Cove, Rock Harbor, and Passage Island

*Lycoperdum marginatum Vitt — On ground under conifers, McCargoe Cove

*Lycoperdum Peckii Morg — On mossy soil, Rock Harbor

*Lycoperdum polymorphum Vitt — On rotten log, Chickenbone Lake

Lycoperdum pusillum Batsch — On ground in old burn, Rock Harbor

Lycoperdum pyriforme Schaeff — On rotten wood, Ryan Island in Siskowit Lake

Lycoperdum pyriforme Schaeff var tessellatum Pers — On ground, Tobin Harbor

Sphaerobolaceae

Sphaerobolus stellatus Tode — On moose dung, McCargoe Cove and Chickenbone Lake

Hymenogastraceae

*Gautiera graveolens Vitt — Just under surface of soil, Rock Harbor Det by C W Dodge

FUNGI IMPERFECTI

*Bothrodiscus pinicola Shear — On dead stems of *Abies balsamea*, Rock Harbor and Mott Island Det by W W Diehl Plate XXII, Figure 4

*Botrytis uredinicola Pk (?) — Following rust infection (*Puc-*

cinia rubigo-vera) on *Thalictrum dasycarpum* Fisch & Lall, at the head of Tobin Harbor

*CERCOSPORA GENTIANICOLA E & E — On *Halenia deflexa* (Sm) Griesb, Rock Harbor Coll by C A Brown

CERCOSPORA SYMPLOCARPI Pk — On *Symplocarpus foetidus* (L) Nutt, Monument Rock Trail from Tobin Harbor Det by E B Mains

*CLADOSPORIUM EPIMYCES Cke — On pileus of old agaric, Ryan Island in Siskowit Lake

CLADOSPORIUM HERBARUM (Pers) Lk — On old *Hydnum erinaceus* (Bull) Fr, Sumner Lake

*CRYPTOSPORIUM NEESII Cda (?) — On dead branches of alder, Rock Harbor

*DIDYMOCLADIUM TERNATUM (Bon) Sacc — On grass, twigs, and moss, Tobin Harbor

*FUSICLADIUM CERASI (Rabh) Sacc — On *Prunus pennsylvanica*, Lake Eva Det by E B Mains

*FUSICLADIUM RADIOSUM (Lib) Lindr — On *Populus tremuloides*, Rock Harbor Det by E B Mains

*GLOMERULARIA CORNI Pk — On living leaves of *Cornus canadensis* L., Lake Eva Trail from McCargoe Cove

*HELICOMA CURTISII Berk — On bark of *Acer spicatum*, at the outlet of Siskowit Lake

ILLOSPORIUM CARNEUM Fr — On *Peltigera sp*, Rock Harbor

*ISARIA BRACHIATA Batsch ex Fr — On old agaric, on conifer log, in swamp, Rock Harbor

*MACROPHOMA ALBIFRUCTA (Pk) Berl & Vogl — On dead branch of *Acer spicatum*, north of Hay Bay

*MACROSPORIUM LEPTOTRICHUM Cke & Ell — On wood of *Abies balsamea*, Duncan Bay The species was originally described from pine and has not hitherto been recorded as occurring on balsam fir

*MACROSPORIUM POLYTRICHI Pk — On capsules of *Polytrichum sp*, Rock Harbor

*MONILIA FUNGICOLA Ell & Barth — On old agaric, at the outlet of Siskowit Lake. The specimens have been compared with the type collection in the Farlow Herbarium The latter shows branched conidiophores, rather than simple conidiophores, as stated in the original description (9).

*Mycosyrinx Osmundae Pk — On *Osmunda regalis* L, Forbes Lake, Clinton (5) says that this is not a smut A Hyphomycete (?)

*Ovularia destructiva (Phil & Plowr) Massee — On *Myrica gale* L, Monument Rock Trail from Tobin Harbor Coll J L Lowe Det by E B Mains

*Penicillium candidum Lk — On gills of old agaric, Ryan Island in Siskowit Lake, on *Fomes applanatus*, Tobin Harbor and Lake Ritchie

*Prosthemium palmatum Earle — On decorticated arbor vitae, Rock Harbor Det by L E Wehmeyer

*Ramularia effusa Pk — On *Vaccinium pennsylvanicum* Lam, Rock Harbor Det by E B Mains

Ramularia Taraxaci Karst — On *Taracacum officinale* Weber, Rock Harbor Det by E B Mains

*Sclerostilbum septentrionale Povah — Among decaying leaves beside brook forming the outlet of Chickenbone Lake Coll by A H Povah This is the material from which both the genus and the species were described (22)

*Septoria Calypsonis Povah — Parasitic on leaves of *Calypso bulbosa* (L) Oakes, Smithwick Island This is the collection from which the species was described (*l c*)

Septoria Violae Westd — On *Viola sp*, Moose Lake, near Tobin Harbor Det by E B Mains

*Sphaeronemella Helvellae Karst — Parasitic upon *Helvella infula* Schaeff, Wallace Lake This species has been found in Manitoba, Alberta, New Hampshire, and Colorado Hone (13) reports the spores as uniseptate, but Bisby (1) states "spores continuous" In our specimens the spores are 1–2-guttulate, with a few of the biguttulate spores showing a septum There is thus in the mature spores a tendency toward a two-celled condition

*Stilbella erythrocephala (Dit) Lind — On moose dung in swamp, Rock Harbor The spores measure 2–6 × 1 4–3 μ

Stilbella sp — On wood of *Abies balsamea*, Duncan Bay The stalks are 0 4–0 8 mm long and bear spores 3–4 × 1–1 5 μ

Stysanus Berkeleyi (Mont) Sacc — On old *Fomes pinicola*, Moose Lake

Tubercularia vulgaris Tode — On alder, Rock Harbor

*Verticillium agaricinum (Lk) Cda — On *Helvella atra*, Chickenbone Lake The specimens are referred to this species, although the spores, which measure 22–32 × 4–4 5 μ, are longer than the size given in the original description

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PLATE XXI

Canker on *Populus tremuloides* caused by *Nectria galligena* Bres. Photographed at the head of McCargoe Cove by C. A. Brown. × about $\frac{1}{8}$

EXPLANATION OF PLATE XXII

FIG. 1. *Thelephora sessilis* Burt, collected at the outlet of Chickenbone Lake, a rare species known previously only from the type collection (photograph by E. B. Mains).

FIG. 2. Perithecia of *Gnomoniella Coryli* (Batsch) Sacc. var. *spiralis* Pk., showing spiral ostiole, enlarged fifteen diameters (photograph by E. B. Mains).

FIG. 3. *Gnomoniella Coryli* var. *spiralis* on leaves of *Corylus rostrata*, showing arrangement of perithecia (photograph by E. B. Mains).

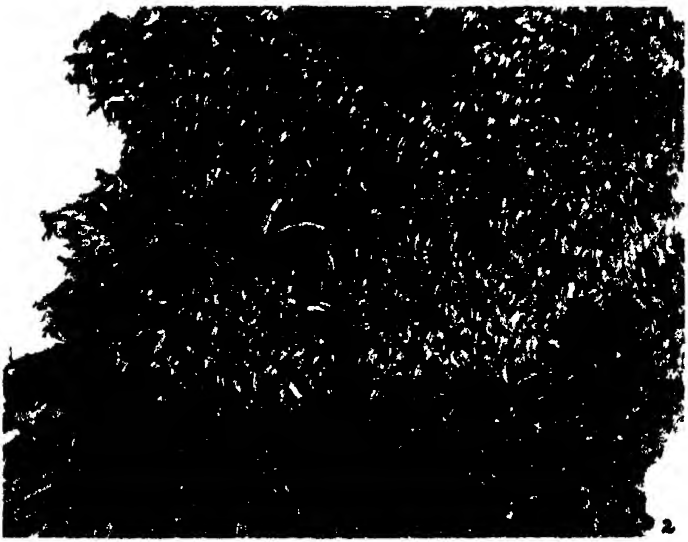
FIG. 4. *Bothrodiscus pinicola* Shear on dead stems of *Abies balsamea* (photograph by E. B. Mains).

PLATE XXII

Fig 1 *Thelephora sessilis*
Figs 2 3 *Gnomoniella coryli* var *spiralis*
Fig 4 *Bothrodiscus pinicola*

PLATE XXIII

1



2

FIG 1 *Onygena corvina* A & S growing on decaying feathers of a sea gull Bat Island (photograph by E B Mains)

FIG 2 *Phialea subcarnea* (Cke & Pk) Sacc growing parasitically upon *Dicranum flagellare* Hedw The photograph by C A Brown, shows at the bottom the dark brown zone of the last year s killed region, in the center the paler moss with apothecia, and above the healthy, uninvaded moss

PLATE XXIV

Polyporus hirtus Quél, which, although usually considered a rare species in both Europe and the United States, is abundant on Isle Royale on the roots of conifers (photograph by F. B. Mains)

NOTES ON MICHIGAN DESMIDS, WITH DESCRIPTIONS OF SOME SPECIES AND VARIETIES NEW TO SCIENCE

GERALD W PRESCOTT AND ANGELINA MAGNOTTA

PAPERS dealing with Michigan algae are surprisingly few, especially since the state is plentifully supplied with favorable algal habitats. The meagerness of published reports on the algae of this region has been referred to by Nichols and Ackley (12), who in 1932 contributed a summarizing list of some 325 species and forms of desmids then known for the state It is significant of the richness of the desmid flora in Michigan that from only four habitats the present authors have identified 46 additional species and forms Some of these are heretofore undescribed species, and many are of special interest because they have not been reported previously from this continent The total number of desmids known for Michigan is now 371

Collections examined in this study came, in the main, from Calhoun and Washtenaw counties We are grateful to Dr A M Chickering for two interesting samples taken from the Sugar Loaf Mountain area in Marquette County These two collections contained a rich variety of desmids although they were not numerous The underlying rock in Marquette County is igneous It is well known that an abundant desmid flora frequently is associated with this type of formation, and no doubt other collections in the area would bear out this in number of individuals as well as in variety The collections which were richest, in both number and kind, were from Calhoun Lake, which lies a few miles to the northeast of Albion, Calhoun County. Interestingly enough the lake was found to have a pH of 5 8, although the larger vegetation and other indications were such that one would suppose it to be alkaline, especially since other lakes in the region are so Thirty or more species of Cosmarium alone were counted on one slide made from washings of *Chara sp* collected in this lake To date nearly half of the known species of desmids for Michigan have been identified from the four habitats indicated

This paper is a preliminary one, for it is expected that from time to time the senior author, at least, will add to the list of Michigan desmids and to the distribution data Study of the desmids has been facilitated by the senior author's iconograph, which includes some 3,000 entries

GONATOZYGON MONOTAENIUM De Bary var PILOSELLUM Nordst, West and West, *British Desmidiaceae*, I 31, Krieger, *Archiv f Hydrobiol*, Suppl 11 158, Pl 3, Fig 7

Width 7 6 μ, length 106 4 μ, cell wall covered with fine, spiny projections Pl XXVI, Fig 17 Calhoun County New for North America

PENIUM RUFESCENS Cleve, West and West, *British Desmidiaceae*, I 99, Pl VI, Figs 12–13

Width 20 0 μ, length 55 0 μ, membrane light yellow-brown, smooth, slightly constricted, and demarked by newer portion Pl XXV, Fig 12 Marquette County Canada (Lowe) Although our plant is smaller than the size usually ascribed to *P rufescens* we questionably assign it to this species on the basis of cell shape, wall constriction, and the approximation of typical coloration

PENIUM LIBELLULA (Focke) Nordst var INTERMEDIUM Roy & Biss, West and West, *British Desmidiaceae*, I 74, Pl VII, Fig 11

Width 24 0 μ, width at poles 10 0 μ, length 111 0 μ Pl XXV, Fig 8 Marquette County Newfoundland (Cushman) This form has relatively broader apices than the typical expression of var *intermedium*, otherwise it is identical

PENIUM CUCURBITINUM Biss f MAJUS West & West, *British Desmidiaceae*, I 95, Pl IX, Figs 19–20

Width 44 8 μ, length 113 0 μ, width at constriction 42 0 μ Pl XXV, Fig 13 Marquette County

Although even larger than f *majus* our specimens seem clearly to belong to it on account of the cell shape, the ridged chloroplast, and the single large pyrenoid in each semicell The typical form of *P cucurbitinum* has been reported from Connecticut, Indiana, and Washington

PENIUM CUCURBITINUM Biss f **minutum** Prescott, f nov — Forma minima, lat 12 5–13 5 μ, long 28 5–30 0 μ Pl XXV, Fig 9 Marquette County

The plant is only half as large as f *minus* W & G S. West

PLEUROTAENIUM NODULOSUM (De Bréb) De Bary, Borge, *Arkiv f Bot*, 19 20, Taf 3, Fig 16–17

Width at constriction 46 8 μ, poles 35 2 μ, length 507 0 μ Pl XXVII, Fig 18 Marquette County Kansas, Nebraska, Cuba

COSMARIUM CAELATUM Ralfs, West and West, *British Desmidiaceae*, III 134, Pl LXXVI, Figs 5–7

Width 42 0 μ, length 51 0 μ, isthmus 15 0 μ Pl XXV, Fig 4 Like the Newfoundland expressions our specimens have four very definite vertical series of slightly larger granules on the facial tumor above the isthmus The basal lobes of the semicells in the plants from northern Michigan show an undulation or a retuse margin that gives a slightly different appearance from the published drawings of this species Marquette County Indiana, Connecticut, New Hampshire, Alaska, Newfoundland

COSMARIUM DENTICULATUM Borge (forma), Borge, *Arkiv f Bot*, 19, No 17 29, Pl 3, Fig 24

Length 175 0 μ, width 105 3 μ, isthmus 39 0 μ Margin of the semicell showing about twenty-two conical, wartlike granules on each side and four or five at the truncated apices, with four or five series of granules within the lateral margins, two rows of granules across the base of the semicell, the granules becoming more prominent in the mid-region just above the isthmus, central part of the semicell without granules, wall densely punctate, chloroplasts two (?) in each semicell Pl XXVII, Fig 14 Calhoun County

This species, new for North America, has been previously reported from Australia, Brazil, and Paraguay Some of our specimens have a resemblance to *C ovale* in shape, and *C denticulatum* should be compared with this species In dimensions our specimens are nearer to *C ovale* than to *C denticulatum* However, the disposition of the granules and the morphology of the chloroplast are in distinct disagreement with *C ovale* On the whole, except for their smaller size, our specimens seem to be identical with, or at least closely related to, a form described by Borge (3, p 29, Taf 3, Fig 24) from Brazil In the Brazilian plant the wall, as in our specimens, has conical warts rather than the spines which characterize the typical form Borge's figure shows four rows of granules across the base of the semicell, whereas our plant has only two

COSMARIUM DIFFICILE Lütkem var SUBLAEVE Lütkem, West and West, *British Desmidiaceae*, III 97, Pl LXXXIII, Figs 4–5

Width 24 0 μ, length 39 0 μ, isthmus 5 5 μ Pl XXVII, Figs 8–9 Marquette County Our plants show a variation in the disposition of the scrobiculations, but otherwise they conform with Lütkemüller's variety Pl XXVII, Fig 9, shows an abnormal plant with three semicells and two isthmi

COSMARIUM HAMMERI Reinsch var PROTUBERANS West & West, *Trans Linn Soc Bot*, Ser 2, 5 246, Pl 14, Fig 35

Width 22 0 μ, length 30 0 μ, isthmus 6 0 μ Pl XXVII, Fig 19 Calhoun County Previously reported for North America by W and G S West, Wolle, and Prescott (14) Prescott lists it for Iowa.

COSMARIUM NORIMBERGENSE Reinsch f DEPRESSUM West & West, West and West, *British Desmidiaceae*, III 53, Pl LXIX, Figs 28–29

Width equal to length, 15 6 $\mu \times$ 15 6 μ Pl XXVI, Fig 6 Marquette County The species is new for North America It is interesting to note that f *depressum* has been recorded previously from the tropics only

COSMARIUM PLICATUM Reinsch, West and West, *British Desmidiaceae*, III 60, Pl LXX, Figs 9–10

Width 38 0 μ, length 62 0 μ, isthmus 20 0 μ Pl XXVII, Fig 1 Calhoun County New for North America

Slightly larger than recorded by W and G S West, with a wall punctated as in f *majus* Reinsch However, our specimens are nearer the typical in shape of semicell

COSMARIUM PORTIANUM Arch. (forma)

Width 35 0 μ, length 41 0 μ, isthmus 15 0 μ Pl XXVII, Fig 10 The typical form is widely distributed in North America and has been reported by Nichols and Ackley (12) from Michigan.

Our specimens show a great similarity to *C pseudobroomei* Wolle, especially in face view. The granulation and the characteristics of the sinus are more like *C Portianum* than the former species.

COSMARIUM PYRAMIDATUM De Bréb var ANGUSTATUM West & West, West and West, *British Desmidiaceae*, II 200, Pl LXIV, Fig 8.

Width 54 5 μ, length 93 6 μ, isthmus 18 0 μ This variety,

as represented in our collections, is not constant in size and form of margin It may have the margin nearly undulated (Pl XXV, Fig 17) This characteristic strongly suggests Borge's f *minus* (3, Taf 2, Fig 3) Calhoun and Marquette counties New for North America

COSMARIUM QUINARIUM Lund, West and West, *British Desmidiaceae*, III 216, Pl LXXXV, Figs 9–10

Width 33–35 0 μ, length 36–39 0 μ, isthmus 9–10 0 μ Pl XXV, Fig 3, Pl XXVII, Figs 4–6 Marquette County

We have noticed variation in the granulation of this species, particularly in the arrangement of granules on the face of the semicell A common form from northern Michigan that we questionably assign to this species (Pl XXVII, Figs 4–6) shows a single, somewhat larger granule just above the isthmus Some specimens of this plant suggest *C polonicum* Racib var *intermedium* Gutw, *Spramozd Kom Fizyogr*, XXX 96, Tab III, Fig 30 Others suggest *C occidentale* Turn var *intermedium* Gutw (*op cit*, p 91, Tab III, Fig 22) The typical form of the species has been found in Calhoun County, Michigan, Maine, Massachusetts, New Hampshire, Wisconsin, and Newfoundland (Taylor)

COSMARIUM REGNELLII Wille f **basigranulatum** Magnotta, f nov — Margines inferiores semicellulae aperte divergentes, margines superiores maxime retusae, apice truncato et retuso, anguli inferiores semicellulae parvis granulis instructi aut tuberculati cum granulo iuxta et intra marginem angulorum basalium, specimen a vertice visum anguste ovatum sed tumidum in regione media, lat 14–16 0 μ, long 18–22 0 μ, isthm 4 0 μ Pl XXVII, Fig 7 Calhoun County

This form seems unquestionably to belong to *C Regnellii* and is placed here on the strength of the forms described by Borge in *Sjön Takerns Fauna och Flora*, 4 16, Taf 1, Fig 15–16 Except for the tubercular thickenings at the angles our form agrees very closely with Borge's figure 16-a''', Taf 1 It should be compared with *C umbilicatum* Lütkem, from which it differs in the main by the absence of an undulation in the upper lateral margins of the semicells.

COSMARIUM SUBCUCUMIS Schmidle (forma)

Width 41.8 μ, length 70 3 μ; isthmus 19.0 μ Wall finely

and densely punctate Pl XXVII, Fig 3 Marquette County Typical form widely distributed in North America

COSMARIUM SUBTUMIDUM Nordst var KLEBSII (Gutw) West & West, West and West, *British Desmidiaceae*, II 193, Pl LXIII, Figs 21–23

Width 28 0 μ, length 38 5 μ, isthmus 7 0 μ Pl XXVII, Fig 2 Calhoun County Previously recorded for North America only from New York, by Burkholder (5)

COSMARIUM TAXICHONDRUM Lund var **unigranulatum** Prescott, var nov — Varietas magna, magno granulo singulo supra et iuxta isthmum, semicellulae a latere visae circulares, granulo utrobique ad basim praeditae, a vertice visae ellipticae, membranum punctatum Lat 45 0–46 8 μ, long 53 0 54 3 μ, isthm 17 0–17 5 μ Pl XXV, Figs 5–6

This form has the shape of the typical form as described by Lundell It is slightly larger, and the margins in the lower part of the semicell are perhaps more nearly parallel than in the type The lack of the two rows of granules on the face of the semicell separates this new variety from the known varieties of the species

COSMARIUM TETRAGONUM (Naeg) Arch var LUNDELLII Cooke f SCHMIDLEI Gutw, *Kom Fizyjog Akad Umiej Krakow*, 32 142

Width 25 4 μ, length 46 8 μ, isthmus 7 8 μ Pl XXV, Figs 1–2

The variety has been reported from New York by Johnson (9), but the *forma Schmidlei* has not been previously reported from this country It is apparently rare in North America, but we have one collection which contains a rather large number of specimens A characteristic of the plant that we have noted and one that has not been mentioned or shown in published figures is the presence of mucilage pores in the upper lateral protuberances as seen in face view There is a similar pore that shows in the wall in the same region when the cell is seen in side view Marquette County

COSMOCLADIUM PUSILLUM Hilse, West and West, *British Desmidiaceae*, V 201, Pl CLVIII, Figs 8–10

Width 10–12 0 μ, length 10–12 0 μ; isthmus 2 0 μ; colonies small Pl XXV, Fig 10 Calhoun County New for North America

Cosmocladium tuberculatum Prescott, sp nov — Cosmocladium mediocre, profunde constrictum, sinu angusto-lineari, semicellulae oblongae sed a fronte visae subreniformes, apice leviter truncato, a vertice visae oblongo-ellipticae, cum inflatione mediana tuberculari utrobique, a latere visae semicellulae subcirculares tumore mediano utrobique, cellulae in colonia paucae et in filo irregulariter ramoso et mucoso positae Lat 11 5–12 0 μ, long 14 5–15 0 μ, crass 9 0 μ Pl XXV, Fig 11 Calhoun County

This form should be compared with *C tumidum* Johnson (9, p 296, Fig 23), from which it differs in the shape of the semicell and in the larger dimensions throughout *C tumidum* is described as having semicells hexagonal-elliptic, width 8 0 μ, length 9 0 μ

Xanthidium antilopaeum (De Bréb) Kuetz var polymazum Nordst, West and West, *British Desmidiaceae*, IV 67, Pl CVIII, Fig 19

Width 53 2 μ, length 57 0 μ, isthmus 14 0 μ Pl XXVII, Fig 17 Calhoun County Widely distributed in North America

Xanthidium Tylerianum W West, *Journ Roy Microsc Soc*, 17 19, Pl 2, Figs 1–4, Pl 3, Fig 14 1889 (*X antilopaeum truncatum* Hastings)

Width 62 4 μ, length 66 3 μ Not figured Marquette County Connecticut, Maine, New Hampshire, New York

Staurastrum aristiferum Ralfs, West and West, *British Desmidiaceae*, V 22, Pl CXXXII, Figs 10–11

Width 26 6 μ, length 38 0 μ, isthmus 6 5 μ Pl XXVI, Fig 20 Calhoun County Newfoundland (Cushman)

Staurastrum Dickiei Ralfs var circulare Turner, West and West, *British Desmidiaceae*, V 5, Pl CXXIX, Fig 16

Width 38 0 μ without spines, 41 0 μ with spines, length 42 0 μ Pl XXVI, Figs 11–12 Calhoun County Connecticut, New York, Washington, Canada.

Our figure is drawn at an angle that makes the sinus appear narrower than typical

Staurastrum maamense Arch (forma)

Width 33 0 μ, length 40 0 μ, isthmus 10 0 μ Semicell in face view showing a series of verrucae within the margin, in vertical view triangular, the pairs of verrucae at the base of the arms so arranged as to form a circle around the smooth central

portion (This circular arrangement of the verrucae appears in Lundell's type drawing of *St pseudocrenatum*, but not in Archer's figure of *St maamense*) Pl XXVI, Figs 14–15 Calhoun County The typical form is reported from California, Connecticut, and Minnesota

Lundell's figure shows three verrucae at the base of the arm rather than two (vertical view) We have found specimens that show a tendency toward verrucae arranged in three's, but in the series at the apex of the lobes rather than at the base

STAURASTRUM MAAMENSE Arch f **atypicum** Magnotta, f nov — Forma major, semicellulae a fronte visae angulis basalibus spina crassa et recta instructis, a vertice visae triangulares, angulis rotundatis sed spina crassa prope apices. Lat 40 0–41 8 μ, long 37 5–38 5 μ, isthm 13 5 μ Pl XXVI, Figs 7–8 Calhoun County

The spine on this form appears to be an extension of the complex verruca at the apex of the lobes of the semicell

STAURASTRUM MONTICULOSUM De Bréb , West and West, *British Desmidiaceae*, V 183, Pl CLIV, Fig 8

Width 39 8 μ, length 42 0 μ, isthmus 15 5 μ Pl XXVI, Fig 5 Marquette County New for North America

STAURASTRUM SEXCOSTATUM De Bréb var PRODUCTUM W West, West and West, *British Desmidiaceae*, V 148, Pl CL, Fig 15

Width 42 0 μ, length 42 0 μ, isthmus 15 0 μ Pl XXVII, Fig 13 Marquette County New for North America

STAURASTRUM SUBORBICULARE West & West, West and West, *British Desmidiaceae*, IV 159, Pl CXXV, Figs 3–5

Width 34 2 μ, length 38 0 μ, isthmus 7 6 μ Pl XXVI, Figs 9–10 Calhoun County New for North America

STAURASTRUM TUMIDUM De Bréb , West and West, *British Desmidiaceae*, IV 142, Pl CXXII, Figs 1–5

Somewhat smaller than the typical, width 78 0 μ, length 97.5 μ, isthmus 45 0 μ Pl XXVI, Figs 3–4 Marquette County Maine, Massachusetts, Pennsylvania

Euastrum Chickeringii Prescott, sp nov — Euastrum mediocre, ⅓-plo longius quam latius, mediocriter constrictum, sinu lineari, levissime dilatum ad apices, semicellulae trilobae, lobis lateralibus concavatis ad marginem, lobo polari paululo extenso, marginibus subrectis ad apicem dilatum; incisura apicali lata et non

profunda, semicellulae magno tumore mediano, tumoribus minoribus iuxta et intra marginem lobulorum loborum basalium, a latere visae quadrato-oblongae apice truncato et angulari cum magna inflatione mediana utrobique et tumoribus minoribus infra hos et ad basim semicellulae Lat 13 8–15 0 μ, long 26 0–27 0 μ, crass 11 0–12 0 μ, isthm 4 5–5 4 μ Pl XXV, Figs 15–16 Marquette County

This plant should be compared with *E cornubiense* W & G S West, *British Desmidiaceae*, II 70, Pl XL, Fig 8 Our specimens have a more extended apical lobe and the side view is quite different in appearance

EUASTRUM CRASSUM (De Bréb) Kuetz var **michiganense** Prescott, var nov — Varietas mediocris, marginibus lateralibus valde incurvatis, incisuris altis at angustis ad utraque latera loborum apicalium, semicellula cum singulo maximo tumore mediano supra et iuxta isthmum, semicellula a latere visa pyramidata, apice truncato, superiore lobo laterali emarginato ut in forma typica, membrana scrobiculata cum scrobiculis magnis Lat 87 0–89 7 μ, long 156 0–159 5 μ, isthm 23 0–25 5 μ Pl XXVI, Figs 1–2 Marquette County

In one collection many specimens were seen (frequently empty cells), so that the cell wall characters which separate this plant from the typical one were fully studied On the whole it presents a somewhat stouter appearance than do the typical forms

EUASTRUM CRASSUM (De Bréb) Kuetz var SCROBICULATUM Lund, West and West, *British Desmidiaceae*, II 7, Pl XXXIII, Figs 7–8

Width 89 7 μ, length 159 5 μ, isthmus 25 5 μ, semicell with four scrobiculations in the central area, arranged to form an inverted Y Pl XXVI, Fig 13 Calhoun County New Jersey, Newfoundland, Cuba

TETMEMORUS BREBISSONII (Menegh) Ralfs f **minutus** Magnotta, f nov

F parva, lat. 24 0 μ, long 90 0 μ. Pl XXVII, Fig 12 Calhoun County.

MICRASTERIAS APICULATA (Ehrenb) Menegh var BRACHYPTERA (Lund) West & West, West and West, *British Desmidiaceae*, II · 101, Pl XLVII, Figs 6–7

Width 146.0 μ, length 205.2 μ, isthmus 30 4 μ, polar lobe

79 8 μ wide Pl XXV, Fig 18 Calhoun County Previously reported from Minnesota only

Our specimens are stouter than the form usually figured

MICRASTERIAS CRENATA De Bréb, West and West, *British Desmidiaceae*, II 85, Pl XLII, Figs 10-13

Width 78 0 μ, length 89 7 μ, cell wall punctate, usually described as smooth Pl XXV, Fig 14 Calhoun County Widely distributed in North America, although reported as rare in Great Britain The stouter polar lobe with convex apex and the rounded angles of the lobules assist in identifying our specimens with *M crenata* The Michigan plants resemble variations of *M truncata*, a similarity that has been frequently noted elsewhere

MICRASTERIAS JENNERI Ralfs, West and West, *British Desmidiaceae*, II 86, Pl XLII, Fig 14, Pl XLIII, Figs 1–2

Width 109 2 μ, length 156 0 μ, isthmus 23 4 μ Pl XXV, Fig 19 Rarely found in our samples and reported but a few times for North America Marquette County Maine, Massachusetts (Prescott), Newfoundland (Taylor)

MICRASTERIAS LATICEPS Nordst var **crassa** Prescott, var nov — Varietas mediocris saepius longior quam latior, apice loborum apicalium magis convexato quam in typo et processibus loborum apicalium verticaliter latioribus, apicibus aculeatis, latis lobis basalibus crassioribus quam in forma typica, sinu angusto subito aperiente ad extremum, membrana cellulae dense sed minute punctata Lat 111 0 117 8 μ, long 121 6–125 0 μ, isthm 19 0 μ Pl XXV, Fig 7 Calhoun and Washtenaw counties

The plants of var *crassa* present a much more compact and stouter appearance than those of the typical form

MICRASTERIAS MAHABULESHWARENSIS Hobson, *Quart. Journ Microsc Sci*, 1863 168

Width 132 0 μ, length 148 0 μ, isthmus 19 0 μ Pl. XXVI, Fig 19 Calhoun and Washtenaw counties

Originally described as subtropical, this plant has a wide distribution in the United States, although it is rare in the British Isles

MICRASTERIAS MAHABULESHWARENSIS Hobson f DICHOTOMA G M Smith, *Trans Wis Acad Sci, Arts and Letters*, 20 345, Pl. 9, Figs 12–14 1922

Width 115 0 μ, length 160 0 μ, isthmus 22 0 μ Pl XXVI, Fig 16 Calhoun County Previously reported for Canada

This is one of the forms of the species which does not appear to be very constant We have one sample containing very many plants that show all manner of intergrading variants between the typical form and the form described by Smith (*l c*) Some specimens show one semicell with the lobules and the other with none

MICRASTERIAS MAHABULESHWARENSIS Hobson var SERRULATA (Wolle) G M Smith, *Roosevelt Wild Life Bull*, 2, No 2 138, Pl XVI, Fig 2

Dimensions of the typical form, but lacking the processes at the apex of the polar lobe Pl XXVI, Fig 18 Calhoun County Minnesota, New Hampshire

MICRASTERIAS RADIOSA Ralfs var ORNATA Nordst, Smith, *Wis Geol Nat Hist Surv Bull*, 57, Part II 47, Pl 60, Figs 3–4

Somewhat smaller than usually recorded, width 203 3 μ, length 212 8 μ, isthmus 17 2 μ Pl XXVII, Fig 11 Calhoun County Previously recorded for Wisconsin

DESMIDIUM COARCTATUM Nordst var CAMBRICUM W West, West and West, *British Desmidiaceae*, V 252, Pl CLXV, Figs 3–4

Width 44 0 μ, length 24 0 μ, width of apex 16–24 0 μ Pl XXVII, Fig 16 Calhoun County Previously reported from Mississippi (Brown, 4)

HYALOTHECA UNDULATA Nordst, West and West, *British Desmidiaceae*, V 239, Pl CLXII, Figs 6–9

Width 6 0 μ, length 13 3 μ, isthmus 4 6 μ, cell wall with a double row of pores around each semicell Pl XXVII, Fig 15 Calhoun County Connecticut, Indiana, New Jersey, New York, Pennsylvania. Described as rare in the British Isles The rows of pores are not shown in figures published in American literature

ALBION COLLEGE
ALBION, MICHIGAN

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EXPLANATION OF PLATE XXV

1-2 *Cosmarium tetragonum* (Naeg) Arch var *Lundellii* Cooke f *Schmidlei* Gutw Fig 1, × 480, Fig 2, × 352

3 *Cosmarium quinarium* Lund , × 480

4 *Cosmarium caelatum* Ralfs, × 480

5-6 *Cosmarium taxichondrum* Lund var *unigranulatum* Prescott, var nov Fig 5, × 480, Fig 6, × 450

7 *Micrasterias laticeps* Nordst var *crassa* Prescott, var nov , × 264

8 *Penium Libellula* (Focke) Nordst var *intermedium* Roy & Biss , × 480

9 *Penium cucurbitinum* Biss f *minutum* Prescott, f nov , × 480

10 *Cosmocladium pusillum* Hilse, × 480

11 *Cosmocladium tuberculatum* Prescott, sp nov , × 480

12 *Penium rufescens* Cleve, × 352

13 *Penium cucurbitinum* Biss f *majus* West & West, × 352

14 *Micrasterias crenata* De Bréb , × 360

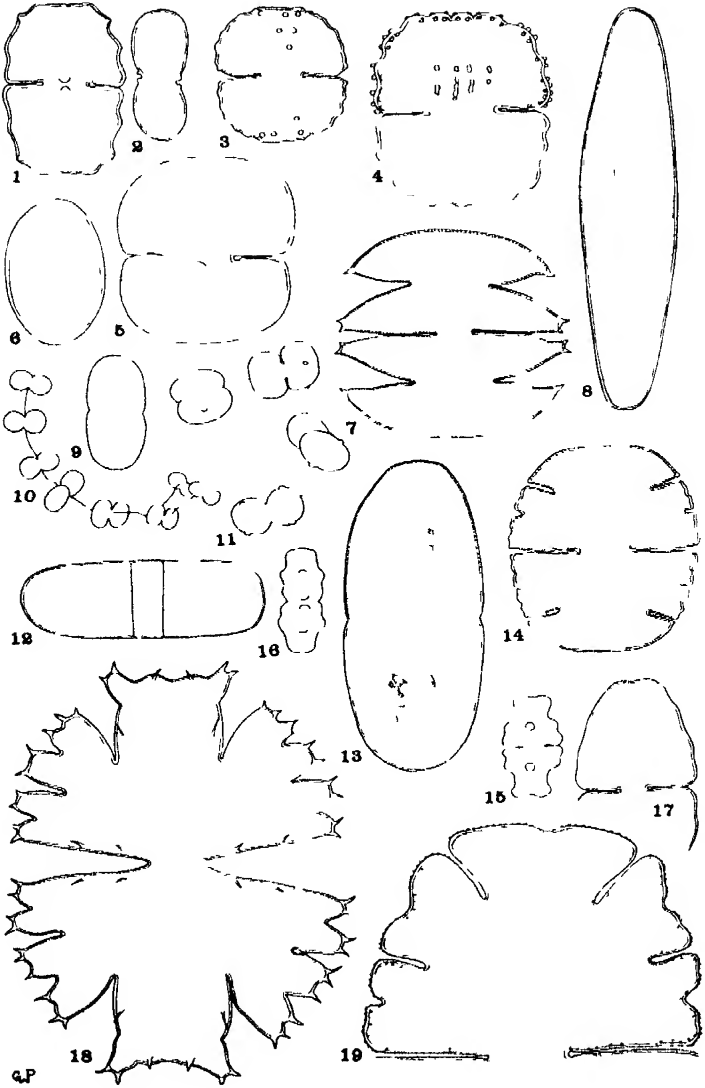
15-16 *Euastrum Chickeringii* Prescott, sp nov , × 480

17 *Cosmarium pyramidatum* De Bréb var *angustatum* West & West, × 480

18 *Micrasterias apiculata* (Ehrenb) Menegh var *brachyptera* (Lund) West & West, × 264

19 *Micrasterias Jenneri* Ralfs, × 352

PLATE XXV



EXPLANATION OF PLATE XXVI

1, 2. *Euastrum crassum* (De Bréb.) Kütz. var. *michiganense* Prescott var. nov. × 352

3, 4. *Staurastrum tumidum* De Bréb. × 352

5. *Staurastrum monticulosum* De Bréb. × 360

6. *Cosmarium nortimbergense* Reinsch f. *depressum* West & West, × 480

7, 8. *Staurastrum maamense* Arch. f. *atypicum* Magnotta f. nov. × 480

9, 10. *Staurastrum suborbiculare* West & West × 480

11, 12. *Staurastrum Dickiei* Ralfs var. *circulare* Turner × 480

13. *Euastrum crassum* (De Bréb.) Kütz. var. *scrobiculatum* Lund. × 352

14, 15. *Staurastrum maamense* Arch. (forma) × 480

16. *Micrasterias mahabuleshwarensis* Hobson f. *dichotoma* G. M. Smith × 264

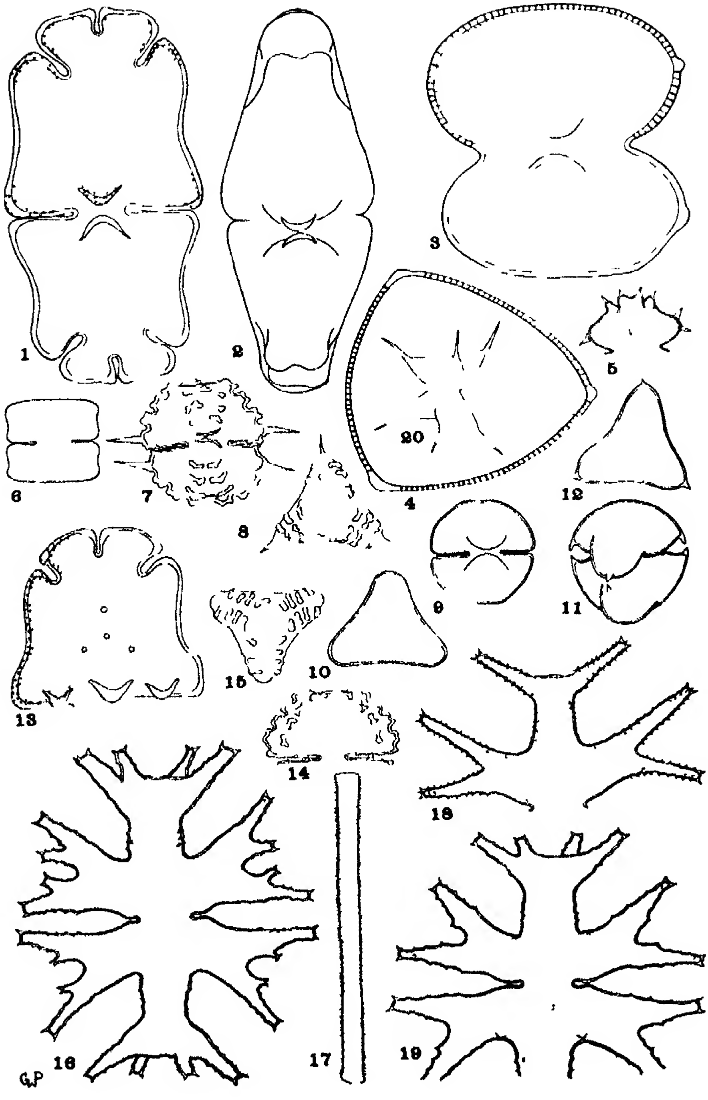
17. *Gonatozygon monotaenium* De Bary var. *pilosellum* Nordst. × 480

18. *Micrasterias mahabuleshwarensis* Hobson var. *serrulata* (Wolle) G. M. Smith × 264

19. *Micrasterias mahabuleshwarensis* Hobson × 264

20. *Staurastrum aristiferum* Ralfs × 480

PLATE XXVI



EXPLANATION OF PLATE XXVII

1 *Cosmarium plicatum* Reinsch × 450

2 *Cosmarium sublumidum* Nordst var *Klebsii* (Gutw) West & West × 330

3 *Cosmarium subcucumis* Schmidle (forma) × 440

4 6 *Cosmarium quinarium* Lund (forma) × 600

7 *Cosmarium Regnellii* Wille f *basigranulatum* Magnotta f nov × 600

8 *Cosmarium difficile* Lütkem var *sublaeve* Lütkem , × 440

9 *Cosmarium difficile* Lütkem var *sublaeve* Lutkem abnormal cell × 440

10 *Cosmarium Portianum* Arch (forma) × 440

11 *Micrasterias radiosa* Ralfs var *ornata* Nordst × 330

12 *Tetmemorus Brebissonii* (Menegh) Ralfs f *minutus* Magnotta f nov × 440

13 *Staurastrum sexcostatum* De Bréb var *productum* W West × 600

14 *Cosmarium denticulatum* Borge (forma) × 440

15 *Hyalotheca undulata* Nordst , × 600

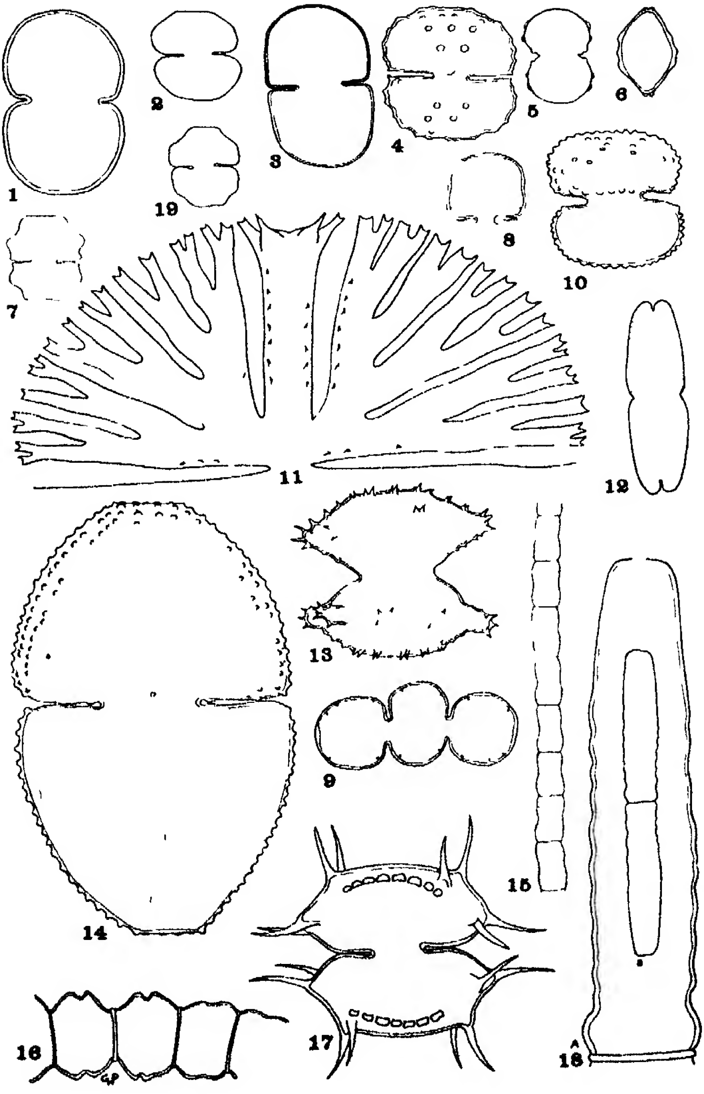
16 *Desmidium coarctatum* Nordst var *cambricum* W West × 600

17 *Xanthidium antilopaeum* (De Bréb) Kuetz var *polymazum* Nordst × 600

18 *Pleurotaenium nodulosum* (De Bréb) De Bary, A × 220, B × 150

19 *Cosmarium Hammeri* Reinsch var *protuberans* West & West, × 440

PLATE XXVII



UNUSUAL AGARICS FROM MICHIGAN II *

ALEXANDER H SMITH

IN THE following account a total of twenty-nine species of agarics are discussed Twenty-seven of these have apparently not been previously recorded as occurring in Michigan

The majority of the collections were made by the writer while collecting with Professor E B Mains in the vicinity of Ann Arbor, in the region around Harbor Springs, and in the Northern Peninsula during the season of 1933 Several species which were collected by the writer in 1929 and determined by the late Professor C H Kauffman, but which have not previously been reported, are also included in this paper The collection numbers and the photographs are those of the writer unless otherwise stated The collections are in the Herbarium of the University of Michigan Thanks are due to Professor Mains for helpful suggestions and criticism during the preparation of the manuscript

BOLBITIUS GLOIOCYANEUS Atk — Singly on sticks in a swampy area, Ann Arbor, Oct 5, 1923 (32–528) Pileus 17 mm broad, convex, glabrous, viscid, evenly "olive-green" [1] at first, becoming "Sanford's brown" when faded, margin slightly striate, lamellae crowded, narrow, adnate, soft, edge white-fimbriate, "jade green" becoming brown from the spores, stipe hollow, 3 cm × 2 mm, white-furfuraceous over all, yellowish green beneath, spores 9–10 5 × 5–5 5 μ, basidia four-spored, 20–22 × 7–8 μ, cystidia lacking on the sides, present on the edge, 30–45 × 6–11 μ, somewhat ventricose but becoming nearly cylindrical, apices narrowed but obtuse, pileus corticated by a layer of inflated pedicellate cells 20–30 × 10–20 μ in diameter

The stipe appeared to have a narrow subgelatinous peripheral region, but did not seem to be viscid when fresh In this respect,

* Papers from the Department of Botany and the Herbarium of the University of Michigan, No 475

[1] All color names in quotation marks are taken from R Ridgway, *Color Standards and Color Nomenclature*, Washington, D C, 1912

in the white-furfuraceous covering, and in the paler colors the writer's specimen differs from that of Atkinson's description The gluten on the pileus, however, is copious and may drip down along the stipe The consistency of the pileus is characteristic of the genus Bolbitius, and the striking color change clearly allies the Michigan collection with Atkinson's species The change in color is very similar to that observed in *Hygrophorus psittacinus,* but the color in age is bright brown instead of yellow, and the green of the young pilei is not so bright

CLITOCYBE CONNATA (Schum) Bres — Cespitose on leaves and débris, near Dexter, Oct 5, 1933 (33–1098). Spores 6–8 × 3 μ, basidia four-spored, 26–28 × 4–5 μ, with clamp connections at their bases, pileus trama homogeneous, differentiated sterile cells and cystidia absent

COLLYBIA EXSCULPTA Fr var RUBESCENTIFOLIA Pk — Gregarious on oak débris, Pinckney, Sept 15, 1932 (32–440) Pileus 8–15 mm broad, convex or slightly depressed at first, becoming more deeply depressed in age, margin remaining decurved, surface subhygrophanous, glabrous, "haematite red" when fresh, fading gradually to a pale yellowish gray in age, lamellae close, narrow, "haematite red" on the margins, greenish yellow below, adnate to slightly decurrent, equal, stipe 1–2 cm × 1–2 mm, greenish yellow above, vinaceous-yellow below, tubular, cartilaginous, fibrillose with yellowish fibrils, slightly bulbous, base covered by a yellowish mycelium, spores 4–4 5 × 2 5–3 μ; hymenium with numerous colored basidium-like bodies

Coker and Beardslee (6) report this variety from North Carolina The "haematite red" color was characteristic of our specimens When dried both the species and the variety have much the same colors and it is quite possible that the variety is merely a dry-weather form Small specimens might be placed in Omphalia because of the broadly adnate or slightly decurrent gills Rea (10) places the species in Marasmius.

CORTINARIUS CROCEOFOLIUS Peck — On sphagnum in a bog, Michigamme, Sept 11, 1933 (33–945) The lamellae were "xanthine orange" in the young pilei, spores 6–7 × 3 5–4 5 μ

CORTINARIUS SUBCINNAMOMEUS Clel (Pl XXVIII) — Scattered on sphagnum in bogs, Marquette, Sept 4, 1933 (33–867), Sept 10, 1933 (33–927), Sept 12, 1933 (33–947), Sept 15, 1933 (33–981),

and at Whitmore Lake, Sept 25, 1933 (33–1008) Pileus 2–6 5 cm broad, conic-campanulate to plane, "Dresden brown" when young, near "Mars brown" in age, innately fibrillose to fibrillose-scaly, dry, lamellae close, broad, near "sulphur yellow" when young, becoming bright "Kaiser brown" to "ferruginous" before the spores mature, adnate or shallowly adnexed, stipe 8–15 cm × 3–10 mm, yellowish above, tawny below, evenly fibrillose, spores 8–10 × 5–6 μ in the Marquette collections, 9–11 5 × 4–6 μ in coll 33–1008, nearly smooth, basidia 38–40 × 6–8 μ, no differentiated sterile elements seen, odor and taste not distinct or faintly resembling that of radish

As Cleland (5) has pointed out, the large spores distinguish this species from *C cinnamomeus* The writer has collected the latter frequently in the same locality from which No 33–1008 was obtained In addition to the difference in spore size, the pileus of *C subcinnamomeus* tends to become quite scaly and its stature is more robust than that of *C cinnamomeus*

Cortinarius triumphans Fr — On humus under hemlock, Wagner's Falls, Munising, Sept 7, 1933 (33–1150) Apparently this characteristically northern species has not been previously reported for Michigan

Entoloma cyaneum Pk (Pl XXIX) — Collected at Wilderness State Park, June 7, 1932 A rather large form, found by Professor Mains and the writer, was growing gregariously under balsam on a sandy ridge, and the following description was made from the fresh specimens pileus 4–10 5 cm broad, obtusely conical at first, then expanded-plane or rather sharply umbonate, surface appressed-fibrillose, becoming subscaly in age, "pale lavender-violet" to "mauvette" when fresh but soon fading to "vinaceous-lilac" and finally "pallid Quaker drab" and unicolorous, margin even and not striate, usually rather abruptly decurved, flesh about 3 mm thick near the stipe and 1 mm near the margin, tapering gradually, lamellae close, broad (5–12 mm), somewhat ventricose, attached by a decurrent tooth only, edge eroded, pale grayish or whitish at first, becoming dull flesh color from the spores, stipe 8–12 cm × 8–12 mm, equal or tapering slightly, hollow, beautifully longitudinally fibrous-striate to apex, furfuraceous above, concolorous with pileus and fading with it, in age becoming nearly white, spores 8–10 × 5–7 5 μ, ellipsoid,

the angles not prominent, basidia four-spored, cystidia none seen on sides, on edge inflated or ventricose with a narrow neck and pedicel, 30–40 × 12–18 μ

This fungus has the stature of a medium-sized Tricholoma, only the smaller specimens approach Leptonia Peck's collection from Shandaken and Worcester, the only one found at Albany, and probably the type, agrees with the fungus described above, but the fungus described by Kauffman as *E cyaneum* in *The Agaricaceae of Michigan*, p 551, differs markedly in the colors and the solid stem

ENTOLOMA GRISEOCYANEUM Fr var ROSEUM Maire — On humus in open woods, Pinckney, Sept 30, 1933 (33–1063) Pileus 3–4 cm broad, plane with a slight umbo, surface dry, innately fibrillose-scaly, disk merely fibrillose, evenly colored, near "vinaceous-brown," "vinaceous-gray" beneath the rosy scales, not striate, lamellae "onion-skin pink," close, adnexed, thickish, narrow to moderately broad, edge eroded, stipe 6–8 cm × 6–10 mm, enlarged evenly toward the base, apex covered by a vinaceous scurfy covering, paler when glabrous, pallid gray below, longitudinally striate, solid, spores angular tuberculate, 8–10 × 4–5 μ, ellipsoid, basidia 30–32 × 8–10 μ, four-spored, sterile elements none

This fungus seems to be very rare in North America, but possibly it has been confused with *E cyaneum* Pk

FLAMMULA ASTRAGALINA Fr — On decayed coniferous wood, Emerson, Aug 25, 1933, coll E B Mains (33–750) Spores 5–7 × 3 5–4 μ, cystidia scattered, 40–45 × 8–12 μ, fusoid-ventricose, apex obtuse or tapering rather sharply, sterile cells similar to cystidia or shorter and more inflated, gill trama composed of a wide central strand of interwoven hyphae bordered on each side by a narrow band of parallel hyphae, pileus trama filamentose, surface covered by a thin gelatinous pellicle

The brightly colored pilei and the gills, which are yellowish when young, serve to distinguish the species macroscopically Bresadola (4) illustrates it very well His spore measurements, however, are slightly larger (7–9 × 3 5–4 μ) than those usually given for the species Kauffman collected this species in Washington, Oregon, and Montana The spores of the Oregon collection (Mt Hood, 1922) measure 6–8 × 3 5–4 μ Cystidia similar

to those of the Michigan collection were found in specimens from Lake Quiniault, Washington, collected by Kauffman, Oct 20, 1925

Galerula cerina (Bres) Atk — On mossy beech logs north of Newberry, near the Superior State Forest, Aug 28, 1933 (33-781)

Galerula coniferarum Murrill (Pl XXX, Fig 3) — On moss on a hummock in a larch bog, Pinckney, Sept 25, 1933 The distant gills separate this species from other small members of the group spores 7–8 × 4 5–5 μ, pileus homogeneous, sterile cells fusoid-ventricose (33–40 × 6–9 μ), cystidia lacking on the sides of the lamellae

Galerula muricellospora Atk — On mossy logs, Superior State Forest, Aug 28, 1933 (33–782), Marquette, Sept 12, 1933 (33-952) Spores 10–12 5 (13 5) × 6–7 μ, minutely roughened, cystidia and sterile cells numerous, 60–70 × 10–12 μ, pileus trama homogeneous

Galerula paludosa (Fr), comb nov — On humus, swampy area, Wagner's Falls, Munising, Sept 7, 1933 (33-897) This is the form illustrated by Fries (Icon T 129, f 3) Pileus trama composed of interwoven hyphae, surface covered by a thin, differentiated gelatinous pellicle, spores 8–10 × 4 μ, basidia 26–28 × 5–6 μ (two- and four-spored), sterile cells 30–35 × 6–9 μ, fusoid-ventricose, cystidia lacking on the sides of the gills, lamellae moderately broad, and broadly adnate as illustrated by Fries

Galerula pistillicystis Atk — On moss near a stream, Munising, Sept 7, 1933 (33–905) Spores 8–10 × 4–4 5 μ, basidia two- or four-spored, pileus trama homogeneous, lamellae distant to subdistant, sterile cells slightly inflated at the base, elongated, with capitate apices The writer's collection differed from Atkinson's description in its white stipe *Galerula hemispherica* has a white stipe and spores which measure 8–9 × 4–5 μ, but it has a different type of sterile cell, as well as subcrowded lamellae

Galerula sulcatipes (Pk) Murr — Singly on black muck in a swamp, Pinckney, July 25, 1933 (33–629), on rotting wood, Ann Arbor, Sept 23, 1933 (33–1006) Pileus 12–15 mm broad, broadly conical, "mummy brown" to "cinnamon-brown" darker on disk, fading to ochraceous-buff, glabrous, hygrophanous, pellucid-striate to the disk, somewhat sulcate in age, very

fragile, lamellae narrow to ventricose, subdistant, narrowly adnate, edge slightly fimbriate at times, cinnamon-brown at maturity, stipe 4 cm × 1 5 mm, pale ochraceous-buff to white from the whitish pruinose-fibrillose covering, longitudinally striate, hollow, fragile, spores 7–9 × 4–5 μ, subellipsoid, smooth, cystidia on the edge of the gills fusoid-ventricose with obtuse apices, 26–45 × 7–12 μ, lacking on the sides, basidia 22–25 × 6–8 μ, four-spored, pileus corticated by a layer of inflated, pedicellate cells

The corticated pileus, fusoid-ventricose sterile cells, small spores, lack of cystidia on the sides of the gills, dark brown pileus, and striate and white stipe distinguish the species

GALERULA TIBIICYSTIS Atk (Pl XXX, Fig 1) — On sphagnum, Mud Lake Bog, Whitmore Lake, Aug 25, 1929, coll A H Smith, determined by C H Kauffman, Mud Lake Bog, Whitmore Lake, Oct 8, 1933 (33–1101), near the Yellow Dog River, Marquette, Sept 9, 1933 (33–913), Michigamme, Sept 11, 1933 (33 941 and 33–942 coll E B Mains) The photograph and the following description were made from collection 33–1101 pileus convex, 8–15 mm broad, glabrous, lubricous, "Sanford's brown" to "chestnut," becoming "ochraceous-tawny" before fading, pale "ochraceous-buff" when faded, margin straight, veil rudimentary but leaving a fringe on the margin for a short time after breaking, lamellae broad, adnate, subdecurrent at times, broadest at base (3–4 mm), tapering to edge, brown when young, cinnamon-brown in age, margin white floccose, subdistant, stipe 2–6 cm × 2–3 mm pale ochraceous, at first covered by sparse fibrils, soon glabrous, pruinose above, equal, fragile, hollow, base slightly bulbose, pileus trama homogeneous, cystidia lacking, sterile cells 40–50 × 9–12 μ, base slightly enlarged, apex subcapitate, spores 10–12 × 7–8 μ, almond-shaped, outer wall appearing wrinkled

HEBELOMA ELATUM Fr (Pl XXXI) — Scattered on sphagnum, Mud Lake Bog, Whitmore Lake, Aug 19, 1929, coll. A H Smith, determined by C H Kauffman, same locality, Oct 14, 1933 (33–1129) Pileus 3–5 cm broad, broadly convex, slightly umbonate or expanded-plane to repand, "fawn color" at first, at length "pinkish cinnamon," margin paler, viscid, pellicle separable, margin even, flesh white, thin on the margin, thick on the

disk, lamellae adnate with a decurrent tooth, narrow, crowded, avellaneous with a tint of cinnamon, edge white-flocculose, stipe 5–9 cm × 5–10 (12) mm equal above the somewhat bulbous base, white to pallid, apex mealy, longitudinally striate, undulate, stuffed, odor resembling radish somewhat, taste slightly bitter, spores 8–10 × 5 5 5 μ, ventricose, slightly inequilateral, basidia 28–30 × 5–6 μ, cystidia lacking on the sides, sterile cells on the edge 65–85 × 4 6 μ, filamentose

The description is drawn up from Professor Kauffman's notes The species was abundant during August, 1929, and October, 1933, but only occasional scattered specimens were found during the intervening period

Hygrophorus squamulosus Ellis (Pl XXXII) – Gregarious on low ground along the edge of a bog, Whitmore Lake, Aug 13 and Sept 1, 1929, coll A H Smith, determined by C H Kauffman The following description is drawn up from his notes pileus 1 5–5 cm broad, convex, obtuse, the disk often slightly depressed, firm, surface dry, cuticle continuous at first but soon breaking up into minute fibrillose scales especially near the margin, "flame scarlet" to "orange chrome," margin yellowish at times, fading to "ochraceous-salmon," flesh firm, concolorous at first but fading to yellowish, lamellae adnate-decurrent, close to subdistant, "apricot yellow" or tinged reddish, broad, thick, stipe 3–5 cm × 3–6 mm frequently compressed, hollow, equal, "apricot yellow" or tinged red, apex white-mealy, glabrous and naked elsewhere, concolorous within except for the white pith, odor and taste none, spores 6 5–8 × 4–5 μ, ellipsoid, basidia 30–32 × 5 μ, four-spored, gill trama parallel, sterile cells filamentose, scattered, 50 × 4 μ

Professor Kauffman notes that it "differs from *H miniatus* in smaller spores, in the frequently compressed stem, the colors, however, seem to be different shades " Although the locality has been visited regularly in the past five years the species has not been found again *H miniatus* was collected in the same locality in 1929 The two species were easily distinguished

Hypholoma Artemisiae Pass (*sensu* Lange) — Collected by C H Kauffman, Sept 13, 1907, but not determined, found again in 1933 by E Nissen and A H Smith (33–1115) on humus in a low elm woods at Stockbridge, Oct 10 The fruit bodies were both

scattered and gregarious Since the material was abundant and since the species is not well known, the following description of the 1933 collection is given pileus 3–7 cm broad, obtusely conical at first, becoming umbonate, plane or with a slightly elevated margin, dry, not appearing hygrophanous, "pale drab" when young, disk at maturity darker and somewhat avellaneous, remainder very pale buff or whitish, colors dull, not striate, surface soft, covered by minute innate fibrils, margin slightly appendiculate, flesh rather thick, watery punctate, white, lamellae narrow (5–6 mm), subdistant to close, widest at the base and tapering to the margin of the pileus, edge even, white when young, becoming dull brown at maturity, stipe 6–12 cm × 4–10 mm , pure white, fragile, hollow, covered by loose fibrils over lower portion, pruinose above and somewhat striate, obscurely undulate, base slightly clavate, spores 8–10 × 4–5 μ, or 10–12 × 4–5 μ, purple-brown under the microscope, slightly curved or flattened in one view, basidia two- and four-spored, sterile cells frequent, 50–60 × 14–16 μ, saccate to ventricose and then the apices obtuse, cystidia scattered, similar to the sterile cells or more cylindrical, pileus trama pseudoparenchymatic near the surface but not corticate

Lange (8) describes the species as rather small, the flesh as hygrophanous, and the gills as crowded The fruit bodies in coll 33–1115 varied greatly in size, the flesh was watery punctate, a character of hygrophanous species, and the gills varied from subdistant to close These differences are not sufficient to separate the two, however Peck's collection at Albany was studied and found to be the same as the Michigan collections The microscopical characters are identical in all three, Peck's collection of 1878, Kauffman's of 1907, and the 1933 collection seem to be the only records of this species for North America

HYPHOLOMA CANDOLLEANUM Fr —Singly in a moist area beside a woodland path, Porcupine Mountains, Ontonagon Co., Sept 14, 1933 (33–955) No cystidia were found on the sides of the gills, those on the edge measure 35–50 × 9–12 μ and vary from fusoid-ventricose to saccate Parker (9) describes the cystidia as "on the edge of the gills only" in his comparison of *H. appendiculatum*, *H Candolleanum*, and *H incertum* In his description of *H Candolleanum* (p 177) he states " . cystidia on edge of gills,

subcylindric, subventricose, projecting 20–35 μ, 9 11 μ in width" On page 166, however, under "phylongetic considerations," he places this species in the Appendiculati and says " *H cinereum*, *H Candolleanum* and *H Inocybeforme* with cystidia on both sides and edge of gills" Apparently the only specimens which he referred to *H Candolleanum* having cystidia on the sides of the gills were those described by Kauffman under the name *H hydrophyllum* Fr (*sensu* Saccardo) The latter fungus, which has been collected frequently in Michigan, has but little resemblance to the specimens here referred to *H Candolleanum*

HYPHOLOMA ECHINICEPS Atk — Closely gregarious or subcespitose near old stumps in pasture land, Ann Arbor, Oct 18, 1931 (two collections), and Sept 27, 1932 (32–489) Parker (9) gives the distribution of this species as entirely within New York

HYPHOLOMA HYMENOCEPHALUM Pk (Pl XXX, Fig 2) — On humus in swampy areas, Lakeland, July 1, 1933 (33–573), and Pinckney, July 18, 1933 (33–581) Pileus 2–3 5 cm broad, convex to obtusely conical, becoming expanded-plane or remaining slightly umbonate, "cinnamon-brown," fading to "pale ochraceous-buff," covered at first by loose fibrous scales, the fibers composed of elongated cells 25–35 × 10–14 μ, glabrous at maturity, slightly corrugated, hygrophanous, sometimes striate, lamellae close, narrow, adnate, equal, whitish at first, slowly changing to purple-brown, stipe 3–6 cm × 2–4 mm, white, dry, dotted with loose fibers, hollow, with large cavity, fragile, tapering upward, pruinose or fibrous-dotted above, odor none, taste unpleasant, spores 7–8 × 3–4 μ, ellipsoid, cystidia none, sterile cells cylindrical or ventricose 45–57 × 9–15 μ, pileus trama covered by a layer of inflated-globose cells. It is entirely possible that *H hymenocephalum* and *H coronatum* are one and the same species *H coronatum* as described by Kauffman (7) is characterized by dark brownish gray colors, but Bresadola's description and illustration (4) easily admit the collections cited here under *H hymenocephalum* Further study in both Europe and America will be necessary to determine accurately the relationship between the two The writer's specimens agree well with the type of *H hymenocephalum* at Albany The fruit bodies in the latter, however, are slightly more robust The twenty-odd additional collections in the Herbarium of the New York State Museum at Albany show too

much variation in size for this difference alone to be given much weight

INOCYBE LONGIPES Kauff — On moss and humus under *Rhus Vernix* in a larch bog near Ann Arbor, Sept 9, 1932 (32-386) This species was described by Kauffman from Welches, Oregon, and has also been collected by him in Washington The young sporophores are nearly white or pale cream color at first, becoming darker as they develop, finally sordid ochraceous yellow or isabelline In moist weather the matted fibrils on the pileus may seem subviscid, but there is no gelatinizing layer

LEPTONIA STRICTIPES Peck — Scattered on sphagnum, George Reserve, Pinckney, July 21, 1933 (33-603) Pileus 1 5-3 cm broad, obtusely campanulate, dry, innately furfuraceous to fibrillose, slightly scaly on the disk in age, evenly colored, "cacao brown" to "pecan brown" or disk "walnut brown," not striate or only faintly so when wet, lamellae close, broad, pallid, then dingy flesh color, adnate, at times decurrent by a short tooth or only by a faint line, edge uneven, floccose, stipe glabrous, cartilaginous, evenly colored, color similar to that of pileus but usually somewhat sordid, odor and taste none, spores 10 8-13 5 × 6 5-8 μ, tuberculate-angular, flesh color in mass, basidia 40-44 × 9-11 μ, four-spored, cystidia none seen, sterile cells basidia-like

The spores of the type measure 10-12 5 × 6-7 5 μ and no differentiated sterile elements were found Apparently this species has been known previously only from the type locality in New York

NAUCORIA MYOSOTIS Fr — On wet ground along the margin of a bog, Ives Lake, Big Bay, Sept 16, 1933 (33-988) Pileus 2-2 5 cm broad, broadly conical to convex, glabrous, or occasionally with fibrillose patches near the margin, viscid to glutinous, "medal bronze" to "citrine," evenly colored, faintly striatulate when fading, and then brownish colors more pronounced, not at all striate when fresh, flesh pallid to dull greenish, lamellae adnate to shallowly adnexed, subdistant, moderately broad, equal to slightly ventricose, whitish to pale olivaceous, becoming brown from the spores, edge white-fimbriate and eroded, stipe 6-8 cm × 2-5 mm, very rigid, covered by white fibrillose patches which blackened in drying, densely pruinose above, hollow, equal, spores 14-16 × 7-9 μ, smooth, slightly almond-shaped, basidia 48-53 ×

10–12 μ, four-spored, cystidia embedded, scattered on sides of lamellae, apex often with several rodlike prolongations, sterile cells filamentose to subfusoid, 35–44 × 6–9 μ, gill trama homogeneous, of short, rather broad cells irregularly arranged, pileus trama differentiated into a rather loose, very gelatinous pellicle, and a body of interwoven filamentose cells The cells of the pellicle and those immediately beneath it were filled with a pale olivaceous content

This collection differs from the descriptions of *N myosotis* given by Rea and Ricken in the presence of embedded cystidia on the sides of the gills These might easily have been overlooked, the specimens are characteristic in all other respects

NAUCORIA PALUDOSELLA Atk — Scattered on moss in a sphagnum bog, usually near or on hummocks, Mud Lake Bog, Whitmore Lake, Sept 25, 1933 (33–1014), and Sept 28, 1933 (33–1041) Pileus 3–5 cm. broad, convex to plane, pale creamy, disk often "tawny," covered when young by tawny, fibrillose, easily removable scales, margin fibrillose, slimy when wet, soon dry and scarcely viscid, lamellae close, sinuate-adnate, moderately narrow (broad in some small pilei), pale yellowish buff, then cinnamon-brown, pliant and soft but tenacious (very hard to section), stipe 3–6 cm × 3 4 mm, pallid above, tawny to russet below, fibrillose or fibrillose-scaly below, pruinose above and buffy yellow, tubular, spores 7–8 × 4–5 μ, subovoid, sterile cells 40–50 × 8 11 μ, cystidia similar to sterile cells, sporadic, i e abundant on one gill and none on others near by, pileus trama made up of a pellicle of narrow, loosely arranged cells with colored walls, body of larger, hyaline cells, gill trama of narrow hyphae This is clearly the plant which Atkinson (1) illustrated and described Because of the rather thick stipe and Flammula-like habit, one is likely to look for it first in Flammula

NAUCORIA VERNALIS (Pk) Sacc — Pileus 1–2 5 cm broad, convex at first, then expanded-plane or slightly depressed, margin slightly decurved and usually with scattered fibrils or fibrillose scales from the broken veil, lubricous, "chamois," "honey yellow," or "clay color," subhygrophanous, finely and closely pellucidly striate on the margin, flesh 2 3 mm thick, tapering gradually to the margin, lamellae crowded and narrow (1 5–2 mm.), broadly adnate, receding in age, edge minutely crenulate,

stipe 4–6 cm × 3–6 mm, with an evanescent apical annular fibrillose zone, veil submembranous at times, concolorous with pileus above, reddish brown below, longitudinally fibrous-striate to the apex, subcartilaginous, spores 6–8 × 3–4 μ, obovate with a truncate base, or subellipsoid, basidia four-spored, cystidia lacking on sides, sterile cells on edge fusoid-ventricose, 35–40 × 8–12 μ, odor and taste none, pileus trama homogeneous

The lubricous cap with its fine crowded striations, pale color, and marginal fibrillose scales, the very narrow crowded gills, and the truncate spores make this a very distinct species. It was either cespitose or gregarious on débris in woods of maple and beech at Harbor Springs, June 4, 1932 (32–46), on coniferous wood at Wilderness Park, June 4, 1932 (32–82), and at Rock River, June 9, 1933 (33–341) These collections correspond closely to the type at Albany, New York Peck's illustration shows a plant with an apical annular fibrillose zone similar to that on the fruit bodies described above The spores of the type measure 6–7 (8) × 3–3 5 μ, are subellipsoid to obovoid, and have truncate bases No cystidia were seen on the sides of the gills, the sterile cells are fusoid-ventricose and measure 30–40 × 8–12 μ Atkinson's photograph (2, Fig. 150) illustrates a more robust fungus, and certain discrepancies in his description indicate that he was probably dealing with a different species

Pluteus hispidulus Fr — Scattered on old beech logs, Blisswood, Harbor Springs, Aug 17, 1933 (33–649), and Aug 20, (33–718) Spores 4 5–6 μ, subglobose in outline, cystidia present on the edges of the lamellae only, 30–36 × 10–12 μ. The Michigan collections of this species, apparently very rare in North America, correspond closely to the illustration of Fries (Icon T 90, f 2)

Tricholoma microsporum Ellis — Scattered on humus along the edge of a bog, Dexter, Sept 14, 1932 (32–405), and Oct 5, 1933 (33–1096) Pileus 3–15 mm broad, obtusely conical when young, remaining so or becoming expanded and slightly umbonate, surface dull, dry, faintly pruinose at first, evenly "deep vinaceous-lavender," but tending to fade to a pale lilac-gray, margin incurved when young, lamellae narrow, slightly ventricose, distant to close, concolorous with the pileus at first but soon fading to pale grayish lilac, adnate, stipe 1–3 cm × 1–1.5 mm, pale lilac to lavender, hoary with a coating of grayish

fibrils, base sordid, odor and taste none, spores 2 5–3 5 × 2–2 5 μ, subglobose to broadly ellipsoid, differentiated sterile cells or cystidia lacking, basidia two- and four-spored

The very narrow (but truly fibrous) stipe and the incurved pileus margin might lead one to look for this species in the genus Collybia

OF MICHIGAN

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PLATES XXVIII–XXXII

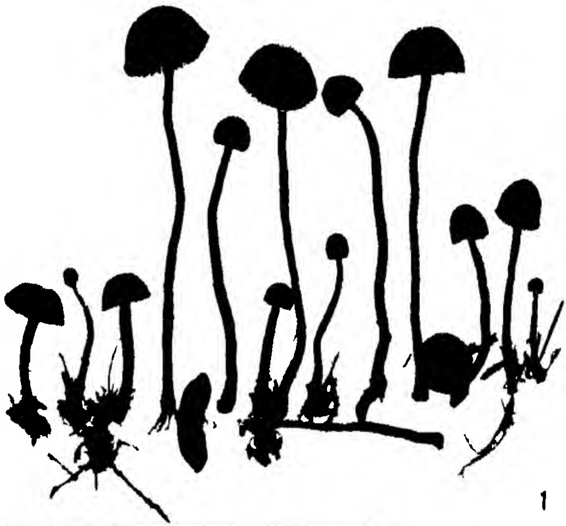
PLATE XXVIII

Cortinarius subcinnamomeus Clel. × 1

PLATE XXIX

Entoloma cyaneum Pk × 1

PLATE XXX



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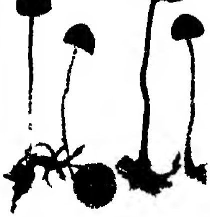

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Fig 1 *Galerula tibiicystis* Atk × 1

Fig 2 *Hypholoma hymenocephalum* Pk × 1

Fig 3 *Galerula coniferarum* Murr, × 1

PL

Fr ×

AT XX

THE FRESH-WATER ALGAE OF NEWFOUNDLAND *

PART II

WM RANDOLPH TAYLOR

IN THIS second part many additional species of desmids and a few other algae are recorded for Newfoundland Part I, in the preceding volume of the *Papers* (19 217-280), deals with general features of the algal flora and lists the Myxophyceae and part of the Chlorophyceae

STAURASTRUM Meyen

STAURASTRUM ALTERNANS De Bréb (Pl XXXV, Fig 6) — L 21-24 μ, w 21 25 μ, isth 7 μ Pools Stas 119, Ingornechoix Bay, 122, Pointe Riche, B 26, Whitbourne

At times the granules tended toward a linear arrangement over the apex, as in the type figured

STAURASTRUM AMERICANUM (W & G S West) G M Smith var LONGIRADIATUM G M Smith f (Pl XXXVIII, Fig 10) — L max 44-58 μ, l body 12-13 μ, w max 40 56 μ, isth 4 5 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

These plants are more like Smith's *S americanum longiradiatum* (1921) than the Wests' *S grallatorium americanum* (1896), from which it was segregated, but differ from both in their much smaller size and depressed apices This plant shows a depressed apex which suggests *S Chaetoceras* (Schröd) G M Smith (1924), but the sinus is very different

STAURASTRUM ANATINUM Cooke & Wills, near var CURTUM G M Smith (Pl XXXIV, Figs 7, 7a) — L body 28 μ, w 47-75 μ Pools. Stas 140, 146, Lookout Mt

STAURASTRUM ANATINUM var TRUNCATUM W West (Pl XXXIX,

* Papers from the Department of Botany of the University of Michigan, No 482

Fig 17) — L max 58–60 μ, w max 79–95 μ, isth 19 μ Pool Sta 140, Lookout Mt

STAURASTRUM ANCHORA W & G S West (Pl XXXVIII, Fig 9) — L 75 μ, w max 113 μ, w body 22 μ, isth 12 μ Pool Sta 140, Lookout Mt

Smaller and with more incurved arms than Smith (1924) reports it from Wisconsin, but agreeing in both size and shape with the Wests' original figures of American specimens (1896*a*), though differing from the description in its relatively longer cells with shorter arms

STAURASTRUM ANKYROIDES Wolle var PENTACLADUM G M Smith (Pl XXXVII, Fig 10) — L 72–77 μ, w max 115–120 μ, w body 18 μ Pool Sta 140, Lookout Mt

In the examples seen the ornamentation was slightly less prominent than in Smith's form (1924)

STAURASTRUM APICULATUM De Bréb (Pl XXXIII, Fig 6) — L 30 μ, w 28 μ, isth 7 μ Pool Stas 112, St John Bay, 122, Pointe Riche

STAURASTRUM ARCTISCON (Ehrenb) Lund (Pl XXXVI, Figs 13–14, Pl XXXVII, Fig 9) — L max 117–132 μ, l body 56–65 μ, w max 120–122 μ, w body 42–49 μ, isth 21 μ Pools Stas 140, Lookout Mt , B 9, St Johns

The Lookout Mt material has longer arms than that from St Johns, the more typical, and more arms to each semicell (about 20 against 15) The Wests (1896) found their American material to have smoother arms than the European, but the Newfoundland specimens do not agree with their var *glabrum*

STAURASTRUM ARCUATUM Nordst Reported by Cushman (1907) from St Anthony

STAURASTRUM ARISTIFERUM Ralfs (Part I, Pl LVII, Figs 1–2) — L max 40–50 μ, l body 21–24 μ, w. max. 38 μ, w body 22–24 μ, isth 6 5 μ Pools. Stas 146, Lookout Mt , F 8, Grandys Brook

STAURASTRUM ARISTIFERUM, f (Part I, Pl LVII, Fig 3). — L max. 70 μ, l body 38 μ, w max 67 μ, w body 34 μ Pool Sta 140, Lookout Mt

STAURASTRUM ARISTIFERUM, f (Part I, Pl LVII, Fig 4) — L max 34 μ, l body 19 μ, w max 38 μ, w. body 13 μ. Pool Sta. 146, Lookout Mt

STAURASTRUM AVERSUM Lund (Pl XXXIII, Fig 7) — L 47 μ, w 42 μ Pool Sta 146, Lookout Mt

STAURASTRUM AVICULA De Bréb var SUBARCUATUM (Wolle) W West (Pl XXXIV, Fig 3) — L 28 μ, w 38 μ, isth 14 μ Pool Sta F 9, Burgeo

STAURASTRUM BICORNE Hauptfl (Pl XXXVIII, Figs 7-8) — L 53–71 μ, w max 73–93 μ, w body 19–27 μ, th 23 μ, isth 10–13 μ Pools Stas 116, St John Bay, 119, Ingornechoix Bay, 122, Pointe Riche

These plants range larger than those cited by Carter (1923), but the minimal dimensions are very close

Staurastrum bioculatum, sp nov [1] (Pl XXXVIII, Figs 3-4) — Cells large, compressed, biradiate, semicells tapered in polar view, with long, hollow, crenate arms at the ends, cask-shaped in end view, irregularly rectangular and transversely constricted in side view, bearing two long, curving, upwardly divergent, hollow, strongly dentate arms with three-aculeate tips at the upper angles, basal denticulations often enlarged to obvious spines, polar area with three papillae on each side, the lateral ones emarginate, the central also slightly apiculate in the center, basal area inflated between the isthmus and the arms, the inflation armed on each side with (usually) two rows of about three spines each, the central spine much larger than the laterals, upper lateral faces of the semicell with two depressed refractive incrassate papillae, cell otherwise smooth, sinus acute, outwardly dilated L max 75 μ, l. body 34–52 μ, w max 94–103 μ, w body 17–18 μ, th 13–17 μ, isth 9 μ Pools Sta 140, Lookout Mt

This attractive species particularly resembles *S urinator* G M Smith, since that has similar, but single, lateral projections, and

[1] **Staurastrum bioculatum, sp nov — Cellulae magnae, compressae, biradiatae; semicellulis aspectu polari angustatis apice bracchia longa vacua crenata ferentibus, aspectu aciali doliiformibus, aspectu faciali irregulariter rectangulis et transverse constrictis bracchia 2 longa divergentia sursum curvata vacua valde dentata apice 3-aculeata ferentibus, bracchiorum dentibus inferioribus saepe magnis, spiniformibus, area polari utrinque 3-papillata, papillis lateralibus emarginatis, media etiamque apiculata, area basali inter bracchia et isthmum inflata, inflatione plerumque 2 seriebus spinarum trinarum armata, seriei spina centrali quam lateralibus conspicue grandiore, semicellulae faciebus superiore parte papillis 2 depressis incrassatis refractivis praeditis, ceterum laevibus, sinu acuto. *Long max. 75 μ, long corp 34–52 μ*, lat max. 94–103 μ, lat corp 17–18 μ, crass corp. 13–17 μ, lat isth 9 μ. Newfoundland, in loco dicto Lookout Mt., legit Bayard Long**

similar rounded basal-lateral contours, but with a different ornamentation The cell body in the present species is longer and the total width greater, although the body is not quite so wide Grönblad's *S dimazum* (Lütkem) Grönbl (1920) has two lateral projections, but they are granulate, the general contours are different, and the plants are smaller, his var *elegantius* is narrower and differs in surface characters The Wests' *S leptocladum insigne* (1896) has a similar, but single, lateral projection, more apical verrucae, and a more delicate form

STAURASTRUM BOREALE W & G S West, var (?) (Pl XXXIX, Fig 12) — L max 31 μ, w max 43 μ, isth 7 μ Pools Stas 116, St John Bay, 122, Pointe Riche

Somewhat like Grönblad's *S affiniforme* (1920), but in *S boreale* the polar area bears definite verrucae and the cells are relatively broader across the arms

STAURASTRUM BOTROPHILUM Wolle (Pl XXXIII, Figs 11, 13) — L 53–57 μ, w 46–49 μ, isth 12–14 μ Seepy slope and stream Stas 129, Doctors Hill (frequent), B 24, Whitbourne

When compared with Wolle's data (1892) these plants appear to be rather large

STAURASTRUM BRACHIATUM Ralfs (Pl XXXV, Fig 21) — L max 40 μ, l body 18 μ, w 38 μ, isth 9 μ Pool Sta F 8, Grandys Brook

STAURASTRUM BRASILIENSE Nordst var LUNDELLII W West (Pl XXXIII, Fig 15) — L max 152 μ, l body 96 μ, w max 130 μ, w body 64 μ, isth 38 μ Pool Sta 140, Lookout Mt

STAURASTRUM BREVISPINUM De Bréb , f near var ALTUM W & G S West (Pl XXXIII, Fig 14) — L 50–52 μ, w 42 μ, isth 15 μ Pool Sta. 140, Lookout Mt

Longer than broad, with upturned mucro at the angles, in which it resembles the cited variety, but in longitudinal dimensions not beyond the species range

STAURASTRUM CERASTES Lund (Pl XXXVI, Fig 15) — L 52–56 μ, w max 63 5–67 μ, isth 17 5 μ Pools Stas 140, 146, Lookout Mt

STAURASTRUM CLEVEI (Wittr) Roy & Biss (Pl XXXVI, Figs 9–10) — L max 60–69 μ, l body 32–38 μ, w max 50–65 μ, w body 22–30 μ, isth 13 μ. Pools Stas 146 (frequent), Lookout Mt , F 8, Grandys Brook

Carter (1923) notes *S Clevei* as smooth, but at least part of the present material is finely punctulate, as well as larger than the British specimens The trispinate arm character shown in Figure 10, lower semicell, is unusual

STAURASTRUM COSMARIOIDES Nordst (Pl XXXIV, Fig 8) — L 75 μ, w 42 μ, isth 13 μ Pool Sta 119, Ingornechoix Bay

STAURASTRUM CRENULATUM (Naeg) Delp , f (Pl XXXVII, Fig 5) — L 19–21 μ, w max 20–24 μ, isth 6 5 μ Pools Stas F 8, Burgeo, B 26, Whitbourne

G S West (1899) figures a series of reduced forms which appear to justify assigning this material to *S crenulatum*

STAURASTRUM CUSPIDATUM De Bréb (Pl XXXIII, Fig 2) — L 24–28 μ, w max 41–65 μ, w body 22–23 μ Pools Stas 119, Ingornechoix Bay, 140, Lookout Mt

STAURASTRUM CUSPIDATUM var CANADENSE G M Smith (Pl XXXIII, Figs 5, 3 f ?) — L max 38–40 μ, l body 19 22 μ, w max 32–40 μ, w body 15–18 μ, isth 5 6 μ Pools Stas 140, Lookout Mt , B 21, Whitbourne

A little small for this variety (Smith, 1924), the apex was depressed The desmid in Figure 3 probably represents a larger form with reduced spines, the dorsal inflation is not a contrary indication The elongate indented isthmus distinguishes it from *S mucronatum*, to which its size gives some resemblance (l 45 μ, w max 43 μ, w body 38 μ, isth 10 μ), it came from Sta 122, Pointe Riche

STAURASTRUM DEJECTUM De Bréb (Part I, Pl LVII, Figs 5–6) — L max 31–39 μ, l body 18–25 μ, w max 24–38 μ, w body 18–28 μ Pools Stas 119, Ingornechoix Bay, 140, 146, Lookout Mt , F 8, Grandys Brook

STAURASTRUM DEJECTUM var PATENS Nordst (Pl XXXIII, Fig 1) — L 28 μ, w max 42 μ, w body 34 μ Pool Sta 116, St John Bay

STAURASTRUM DICKIEI Ralfs (Pl XXXIII, Fig 12) — L 34 μ, w max 48–66 μ, w body 36–43 μ Pools Stas 119, Ingornechoix Bay; 122, Pointe Riche, B 21, Whitbourne

STAURASTRUM DILATATUM Ehrenb (Pl XXXV, Fig 9) — L 28–30 μ, w 24–31 (–48 ?) μ, isth 9–10 μ Ditches, pools, and wet moss Stas 129, Doctors Hill, 135, Pointe Riche, 103, McIvers Cove, B 6, 9, 20, St Johns, B 24, Whitbourne

Some of the material had a well-differentiated ring of granules about the isthmus, as figured

Staurastrum dubium W West — Reported by Cushman (1907) from Rose-au-Rue

Staurastrum echinatum De Bréb — Reported by Cushman (1907) from St Anthony For the various interpretations of this species see Heimans (1926)

Staurastrum elongatum Barker (Pl XXXVI, Figs 1–2) — L 60 μ, w max 40 μ Pools Stas 146, Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook

Donat (1927) accepts a southern coastal plain distribution in America for this plant, but in Europe (Carter, 1923) it is northern

Staurastrum Fernaldii, sp nov [2] (Pl XXXVI, Fig 5) — Plant small, semicells triangular in polar view, the sides slightly concave, the angles produced into stout processes with 5–7-denticulate flattened ends, three or four rings of acute granules encircling each arm, causing the margins to appear dentate, and two or three granules within the margin on obsolete processes, central area smooth, semicells in side view subcylindrical below, a little swollen near the isthmus, the swelling surmounted by a row of acute granules, the upper angles extended into stout hollow processes as described above L 38 μ, w max 28–29 μ, w base body 9 5 μ, isth 6 5–7 0 μ Pool Sta F 8, Grandys Brook

This plant shows similarities to *S Zygaena* W. & G S West (1896), but that plant is relatively wider and differs in surface details It is also somewhat like *S margaritaceum*, but has longer body and arms

Staurastrum furcatum (Ehrh) De Bréb (Pl XXXIV, Fig 2, Pl XXXVII, Fig 14, f) — L max 40–47 μ, l body 22–30 μ, w max 34–38 μ, w body 18–22 μ, isth 11 5 μ Pools. Stas 140, Lookout Mt, F 6, Great Barachois.

[2] **Staurastrum Fernaldii**, sp. nov — Planta parva, semicellulis aspectu polari triangularibus; lateribus paulo concavis; angulis in bracchia 5–7-denticulata apice planata productis, marginibus de causa granulorum acutorum ter quaterve verticillate bracchia circumstantium dentatis, granulis intramarginalibus 2 vel 3; area centrali laevi; semicellulis aspectu laterali deorsum subcylindricis, prope isthmum subinflatis, inflatione granulorum acutorum annulo circumdata, angulis superioribus in bracchia crassa vacua productis Long 38 μ, lat max 28–29 μ, lat corp bas 9.5 μ, isth. 6 5–7.0 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

The processes varied from rather slender and solid near the forked ends (notably from Sta F 6), to short and hollow throughout

STAURASTRUM FURCATUM, var (?) (Pl XXXVI, Fig 11) — L max 36–40 μ, l. body 22 μ, w 43–47 μ, isth 7 5 μ Pool Sta 146, Lookout Mt

The processes in this variety are slender, not always hollow throughout, the semicells are triangular with the upper series of processes borne on an elevated apex, the lower margins are nearly smooth except that in many instances they are characteristically set with a single long (3–4 μ) spine Rich (1932) recognizes the presence of such a spine in *S furcatum* Grönblad (1920) accepts as *S Tohopekaligense* forms with 2 series of upper processes Prescott (1931) figures a short-armed form as *S Tohopekaligense trifurcatum* which suggests this plant

STAURASTRUM FURCATUM var ACULEATUM Schmidle (?) (Pl XXXVII, Fig 6) — W max 36 μ, w body 21 μ Pool Sta F 8, Grandys Brook

STAURASTRUM FURCIGERUM De Bréb (Pl XXXVI, Figs 7–8) — L max 70–72 μ, l body 30–35 μ, w max 51–80 μ, w body 22–38 μ, isth 15 μ Pools Stas 116, St John Bay, 122, Pointe Riche, 119, Ingornechoix Bay, 140, Lookout Mt , B 6, St Johns

The range of length of arm seems to be considerable in this material The form shown by Figure 7 resembles var *armigerum* except for the number of arms in the upper series

STAURASTRUM FURCIGERUM var EUSTEPHANA (Ehrenb) Nordst — Pool Sta 119, Ingornechoix Bay

STAURASTRUM GEMINATUM Nordst , near var LONGISPINUM Printz (Pl XXXV, Figs 10–11) — L max 40–47 μ, l body 28–30 μ, w max 31–36 μ, w body 19–28 μ Pool Sta 146, Lookout Mt

The spines are a little shorter and there are two more at each angle than figured by Printz (1915), with the semicells less rounded in side view The material is also suggestive of *S hystrix* Ralfs, Allorge's figures of that species (1930) are more like Figure 11 of the present material than the figure used by Carter (1923), but their plants were smaller

STAURASTRUM GRACILE Ralfs (Pl XXXIX, Fig 13) — W max 57 μ Pool. Sta. 116, St John Bay

STAURASTRUM GRALLATORIUM Nordst , var (Pl XXXIX, Fig 18) —

Cell large, biradiate, semicells truncate-triangular, the distal angles prolonged into stout slightly divergent arms, the base slightly and abruptly contracted into a shallow sinus, arms from the side terminated by two stout spines nearly in the plane of the cell, with the outer spines larger than the inner, upper and lower margins serrate, the upper accentuated by a dorsal row of apiculae, the sides bearing a row of smaller apiculae, cell body from the side showing two rows of granules above the sinus and two rows below the bases of the arms, with the apical ornamentation across the crest, cell apex showing a broadly oval body extended into the stout arms, the cell faces obviously thickened, the top showing a pair of erose or three-denticulate verrucae on each side, and two spines at the junction with each arm, the area between sparsely granulate L max 80 μ, l body 60 μ, w max 96 μ, w body 22 μ, th 24 μ, isth 9 5 μ Pool Sta 140, Lookout Mt

Larger than the species, and particularly resembling but also larger than the var *forcipigerum* Lagerh , which Smith (1924) reports as having one asymmetrically placed spine at each arm base

Staurastrum grande Bulnh var parvum W West (Pl XXXIV, Fig 9) — L 65 μ, w 56 μ, isth 17 5 μ Pool Sta. 140, Lookout Mt

Staurastrum Heimerlianum Lütkem , f (?) (Pl XXXVII, Fig 3) — L body 16 μ, l max. 21 μ, w 28 μ, isth 5 5 μ Pool Sta F 8, Grandys Brook

Staurastrum inflexum De Bréb (Pl XXXV, Fig 16) — L 19 μ, w max 38 μ, w body 10 μ, isth 4 5 μ Pool Sta. 116, St John Bay

Staurastrum iotanum Wolle (Pl XXXV, Fig 14) — L max 19 μ, l body 10 μ, w max 22 μ Pool Sta 146, Lookout Mt

Staurastrum Johnsoni W & G S West (Pl XXXVIII, Figs 5–6) — L max. 63–75 μ, l body 45–58 μ, w max. 84–103 μ, w body 13–17 5 μ, isth 9 5 μ Pool Sta 140, Lookout Mt

As originally described (1896), the arms were nearly parallel, Smith (1924*a*) accepts the diverging arms, Smith again (1924*b*) figures diverging arms, but with a different type of lateral ornamentation on the semicell faces, the subapical rings of granules which he figures (1924*a*, *b*) are reduced to strong verrucae, but

his var *depauperatum* shows a similar simplification, Grönblad's var *perpendiculatum* (1921) has divergent, slightly curved arms like those of the Newfoundland material, but his plants were somewhat larger Cushman's var *coloradense* (1904) has rougher arms and is shorter

STAURASTRUM LEPTOCLADUM Nordst, f (Pl XXXIX, Fig 19) — W 84–120 μ Pools Stas 140, 146, Lookout Mt

The polar area bears upon each side two small aculei, of unequal size, on a slightly developed verruca It is near the var *cornuta* of Wille

STAURASTRUM LONGISPINUM (Bail) Arch var BIDENTATUM (Wittr) W & G S West (1902) — Reported by Cushman (1907) from St Anthony

STAURASTRUM MACROCERUM Wolle — Reported by Cushman (1907) from St Anthony

STAURASTRUM MARGARITACEUM (Ehrenb) Menegh, f (Pl XXXVII, Fig 1) — Cell small, body of semicells short, tapered slightly toward the isthmal constriction, smooth except for the basal angle with one row of granules, and the polar area with a bigranulate verruca near the margin between the arms, arms usually five, margins denticulate, surface with 3–4 rings of granules, ends 5–7-denticulate L 32 μ, w max 35 μ, w body 14 μ, isth 9 μ. Pool Sta F 6, Great Barachois

STAURASTRUM MERIANI Reinsch (Pl XXXV, Fig 15) — L 42 5 μ, w 23 7 μ Rill Sta 134, Pointe Riche

STAURASTRUM MUCRONATUM Ralfs, large f (Pl XXXIII, Fig 8) L 37 5 μ, w max 51 μ, w body 39 μ Pool Sta 119, Ingornechoix Bay

This plant differs from the type principally in size, but var *subtriangulare* is large Some figures of Smith's *S dejectum inflatum* (1924) suggest this material, but Carter's do not (1923)

STAURASTRUM MUCRONATUM var SUBTRIANGULARE W & G S West (Pl XXXIII, Fig 4) — L max 36–43 μ, l body 35–36 μ, w max 42–49 μ, w body 33–38 μ, isth 9–13 μ Pool Sta 122, Pointe Riche

STAURASTRUM MURICATUM De Bréb, f (Pl XXXV, Fig 4) — L 48–56 μ, w 37 38 μ, isth 11 μ Pools, wet banks, and ditches Stas 134, Pointe Riche, 102 (frequent), 103 McIvers Cove, B 28, 29, Whitbourne

STAURASTRUM NANUM Wolle — Reported by Cushman (1907) from Rose-au-Rue

STAURASTRUM NATATOR W West (Pl XXXVIII, Figs 1–2) — L max 66–75 μ, l body 36–38 μ, w max 85–88 μ, w body 11–15 μ, th 14–16 μ, isth 9 5 μ Pools Stas 140, Lookout Mt, B 26, Whitbourne

Notable points of variation include a length over all somewhat greater than in the British (Carter, 1923) and Wisconsin (Smith, 1924*a*) plants, an additional row of granules near the isthmus, and rings of pores (or granules?) below the apical verrucae The Wests' figures (1896) of American var *crassum* and their measurements show a much thicker cell, Smith's figure (1924*a*) of type material is closer to the present form

Staurastrum novae-terrae, sp nov [a] (Pl XXXVI, Fig 4) — Cells of moderate size, semicells from polar view triangular, the sides straight or slightly concave, truncate-triangular from side view, the polar area hardly elevated, the angles with long, smooth divergent processes, solid or slightly excavate at the base, bifurcate at the tip into two stout spines, top with a series of three pairs of short, divergent, solid, bifurcate processes, one on each side of each angle, inserted well within the margin, sides usually denticulate below each angle, but otherwise contour unbroken, sinus open, nearly 90°, wall minutely punctulate L max 28–45 μ, l body 25–28 μ, w max 38–50 μ, w body 22–23 μ, isth 7 5–9 5 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

This plant differs from *S pseudopelagicum* and *S pelagicum* in the upper series of processes, and apparently from the former in its solid arms, though the latter has its (shorter) arms solid The longer arms and the triangular semicells and this character of solidity separate the material from *S furcatum* and *S Toho-*

[a] **Staurastrum novae-terrae,** sp nov - Cellulae mediocres, aspectu polari triangularibus, lateribus rectis vel subconcavis, aspectu laterali triangularibus, area polari vix elevata, angulis bracchiis longis laevibus divergentibus solidis vel basi paulo excavatis praeditis, apice bifurcatis spinas 2 validas ferentibus, superficie seriem certe inframarginalem appendicum 6 divergentium solidarum bifurcatarum regulariter geminatim positarum ferente, lateribus plerumque infra angulos dentatis alioqui integris, sinu aperto, subrectangulo, membrana minutissime punctulata Long max 28–45 μ, long corp 25–28 μ, lat max 38–50 μ, lat corp 22–23 μ, lat isth. 7 5-9 5 μ Newfoundland, in loco dicto Lookout Mt, legit Bayard Long

pekaligense These several plants have more superficial resemblances than close relationships to the present

STAURASTRUM O'MEARII Arch (Part I, Pl LVII, Figs 7, 7*a*) — L max 17–21 μ, l body 15 μ, w max 25 μ, w body 15 μ Pool Sta 145, Lookout Mt

STAURASTRUM OPHIURA Lund (Pl XXXVII, Figs 11, 13) — L 47 μ, w max 103–141 μ, w body 22–28 μ, isth 15 17 μ Pools Stas 140, Lookout Mt, F 8, Grandys Brook

This material lacked granules on the swelling above the sinus

STAURASTRUM ORBICULARE Ralfs var EXTENSUM Nordst, f (Pl XXXIII, Fig 9) — L 30–32 μ, w 26–28 μ, isth 8 5–9 5 μ Pools and wet moss Stas 140, Lookout Mt, B 6, 9, 20, St Johns, B 21 (frequent), 24, Whitbourne

Though the species assignment of this material seems clear, it was not certain that it agreed with any of the named varieties In general, var *extensum* seemed most suitable, but some cells were more like var *depressum*, and there did not seem to be any clear segregation possible, the plants are a little small for var *extensum*

STAURASTRUM PACHYRHYNCHUM Nordst (Pl XXXIV, Fig 1) — L 24–36 μ, w 24–30 μ Pools Stas 135, Pointe Riche, 119, Ingornechoix Bay, 148, The Tableland

Borge's form (1903) has more slender arms than the material at hand, which is close to the form reported by Raciborski (1889), but without any inflexion of the angles

STAURASTRUM PARADOXUM Meyen (Pl XXXV, Figs 17–18, 19?) — L max 42 μ, l body 26 μ, w max 38–56 μ, w body 15–17 μ Pools Stas 140, 146 (frequent), Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook

Smith (1924*a*) distinguishes *S gracile* as having intramarginal paired granules in vertical view, *S paradoxum* as lacking them, whereas Carter (1923) appears to admit them as occasional ornamentation

STAURASTRUM PELAGICUM W & G S West var **longibrachiatum,** var nov [4] (Pl XXXVI, Fig 3) — Plant of moderate size, polar view triangular, the angles produced into solid processes, lateral

[4] *Staurastrum pelagicum* var **longibrachiatum,** var nov — Planta mediocris, aspectu polari triangula, angulis in bracchia solida bifurcatis, semicellulis aspectu laterali triangulis ad sinum truncatis, angulis superioribus in bracchia sursum divergentia bifurcata productis, area polari laevissime inflata et asperata, mar-

view of semicells truncate-triangular, the upper angles produced, the processes upwardly divergent, bifurcate, the polar area very gently inflated and roughened, lateral margins slightly curved, barely roughened, sinus widely open, acute L max 42 μ, l body 25 μ, w max 48 μ, w body 30 μ, isth 7 5 μ Pool Sta 146, Lookout Mt

There is much about this plant to remind one of *S pseudopelagicum* W & G S West, but here the slender arms, much longer than those in the species, are solid, and the Wests (1903) describe their plant as hollow-armed The granulation characteristic of the species is reduced and noticeable along the edges only *S subcruciatum* Cooke & Wills does not have long slender arms like those of this material

STAURASTRUM LENTACERUM (Wolle) G M Smith (Pl XXXVII, Fig 12) — W max 95–160 μ, w body 21 24 μ Pools Stas 140, 146, Lookout Mt

STAURASTRUM POLYMORPHUM De Bréb (Pl XXXVII, Fig 4) — L 28 μ, w 36 μ, isth 10 μ Pool Sta F 9, Burgeo

This plant greatly resembles Smith's drawing of Norwegian *S gracile* (1924*a*), but the writer's plants are far too small to meet his size requirements

STAURASTRUM POLYMORPHUM, f (Pl XXXIV, Fig 4) — L 30 μ, w 24 μ, isth 8 5 μ Pool Sta 145, Lookout Mt

Except for size, these individuals rather suggested var *pusillum* W West

STAURASTRUM POLYTRICHIUM (Perty) Rabenh , f (?) (Pl XXXIX, Fig 15) — L body 47 μ, w body 39–41 μ Wet moss in pools Stas 130, Doctors Hill, B 6, St Johns

The subacute sinus open, the spines 3 5 μ long, in aspect these plants tended toward *S pilosum* of Carter (1923, Pl 138, Fig 3), but see Heimans (1926), the lateral angles from side view were more rounded and the apex was too curved for *S Brebissonii truncatum* Grönblad (1926)

STAURASTRUM PROTECTUM W & G S West, near var PLANCTONICUM G M Smith — L body 23 μ, w max 43 μ, w body 28 μ Pool Sta 122, Pointe Riche

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ginibus lateralibus paullulo curvatis vix asperatis, sinu late aperto, acuto Long max 42 μ, long corp 25 μ, lat max 48 μ, lat corp 30 μ lat isth 7 5 μ Newfoundland in loco dicto Lookout Mt , legit Bayard Long

Small, and relatively short for Smith's Wisconsin variety (1924*a*)

STAURASTRUM PUNCTULATUM De Bréb (Pl XXXV, Fig 8) — L 28 34 μ, average 33 μ, w 26–31 μ, average 29 μ, isth 9 0 9 5 μ Ditches, pools, boggy slopes, and cliffs Stas 129, Doctors Hill, 140, Lookout Mt , 102, 103, McIvers Cove, F 6, Great Barachois, B 24, 28, Whitbourne, B 6, 9, St Johns

STAURASTRUM PUNCTULATUM var PYGMAEUM (De Bréb) W & G S West (Pl XXXV, Fig 7) — L 37–38 μ, w 25 33 μ Mosses on wet slope, and pool Stas 129, 130, Doctors Hill (frequent)

STAURASTRUM PYRAMIDATUM W West (Pl XXXIII, Fig 10) L 48–54 μ, w 40 44 μ Ditch Sta B 28, Whitbourne

These cells were distinctly flattened at the poles Since this is the distinguishing feature in contrast to *S muricatum* the present name is applied, although in size the plants, being rather small, seem nearer to the latter species

STAURASTRUM QUADRISPINATUM Turn (Pl XXXV, Fig 2) — L max 28 42 μ, l body 23 24 μ, w max 35–41 μ, w body 18 19 μ, isth 9 5 μ Pool Sta 146, Lookout Mt

These plants agree excellently in shape, but are smaller than the British (Carter, 1923) ones

STAURASTRUM RAVENELLII Wood — L 34–36 μ, w 32 40 μ, isth 9 5–11 0 μ Ditch Sta B 28, Whitbourne

STAURASTRUM ROTULA Nordst (Pl XXXVII, Fig 8) – L 48 μ, w max 80–105 μ, w body 28 μ, isth 17 μ Pool Sta 140, Lookout Mt

The papillae of the central area are hardly truncate in this material, Smith (1924*a*) and Wolle (1884) find theirs truncate, but the Wests (1896) do not

STAURASTRUM SEBALDII Reinsch var ORNATUM Nordst (Pl XXXIX, Fig 16) – W 115 μ, isth 20 μ Wet moss Sta B 6, St Johns

STAURASTRUM SETIGERUM Cleve (Pl XXXIV, Fig 10, Pl XXXVII, Fig 7) — L max 47 μ, l body 41 μ, w max 40 μ, w body 27 μ Pools Stas 122, Pointe Riche, F 8, Grandys Brook

Differentiation of the spines at the cell angles was not very pronounced in this material, and the cells were small

STAURASTRUM SIBIRICUM Borge var OCCIDENTALE W & G S West (Pl XXXIV, Fig 6) — L max 28 μ, l body 24 μ, w (arm to face) 28 μ, isth 11 μ Wet moss Sta 130, Doctors Hill

Staurastrum Simonyi Heim — Pool Sta 146, Lookout Mt

Staurastrum striolatum (Naeg) Arch (Pl XXXV, Fig 5). — L 16–22 μ, w 18–21 μ Pools Stas 140, Lookout Mt , B 26, Whitbourne

Staurastrum subcruciatum Cooke & Wills (Pl XXXVI, Fig 6, Pl XXXIX, Fig 14) — L max 31–35 μ, l body 22 5–26 μ, w max 35–42 μ, w body 25–28 μ, isth 7 5 μ Pool Stas 119, Ingornechoix Bay, 122, Pointe Riche.

The first specimen figured has an extreme reduction of the narrowed arm tips They were sometimes more attenuate and typical In one case the dorsal spines were all cleft at right angles to the first forking

Staurastrum subgracillimum W & G S West — W max 50–65 μ, w body 12 μ, l 15 μ, isth 5 6 μ Pools Stas 119, Ingornechoix Bay, 140, Lookout Mt

Staurastrum subnudibrachiatum W & G S West, var (Pl XXXV, Fig 20) — L max 24 μ, l body 13 μ, w max 30 μ, w body 9 μ Pool Sta F 8, Grandys Brook

The forms in Figures 20 and 21 seem to have little in common, but West (1899) admits to *S brachiatum* plants with two- and three-angled apices, and obtuse or acute sinuses However, since the shape agrees far better with that of *S subnudibrachiatum*, the present specimens are assigned to it, in spite of the difference of size, which would have a contrary significance

Staurastrum subscabrum Nordst, near f scabrior W West (Pl XXXV, Fig 1) — L 34–48 μ, w 36–47 μ, isth. 12–13 μ Pool and ditch Stas. 140, Lookout Mt , B 28, Whitbourne

The spines on the material of Station 140 were fewer and coarser, more truncate or bidentate, than those of the figure, and the cell angles were more rounded

Staurastrum teliferum Ralfs (Pl XXXV, Fig. 3) — L. 40–47 μ, w max. 32–52 μ, w body 28 5–43 μ, isth 14 μ Pools Stas 122, Pointe Riche, 119, Ingornechoix Bay, 146, Lookout Mt., F 8, Grandys Brook

Staurastrum tetracerum Ralfs (Pl XXXV, Fig 12) — L max. 28–31 μ, l body 8 5 μ, w max 22–32 μ. Pools. Stas.: 116, St John Bay, 119, Ingornechoix Bay, 146, Lookout Mt

Staurastrum tetracerum f trigonum Lund (Pl XXXV, Fig. 13)

— L max 25–30 μ, l body 10 μ, w max 24–28 μ, w body 7 5 μ Pools Stas 119, Ingornechoix Bay, 140, Lookout Mt

STAURASTRUM VESTITUM Ralfs (Pl XXXVI, Fig 12) — L 24 μ, w 60 μ Pools Stas 140, 146, Lookout Mt

EUASTRUM Ehrenb

EUASTRUM ABRUPTUM Nordst f MINUS W & G S West (Pl XXXIX, Fig 1) — L 22–28 μ, w 18–22 μ, isth 4–5 μ Pool Sta B 26, Whitbourne

This material resembles the Wests' *E denticulatum* (1905) in their Figure 4 only, Nordstedt (1908) suggests that the type of the form may belong there

EUASTRUM ALLENII Cushm (Pl XLI, Fig 5) — Cell about twice as long as broad, cell ends abruptly narrowed, rounded, projecting, with linear incision, semicells nearly rectangular at the base, with a slight undulation just beyond, sides with two marked clefts, approximately dividing the distance below the contracted apex into thirds, the more basal about half as deep as the other, acute but widely open, the other cleft deep and acute, open without but nearly linear toward its apex, width greatest across the upper lateral lobes, less across the basal angles, faces with three rounded conical swellings near the base of the semicells and projecting toward the isthmus, wall thick, coarsely to finely punctate, with the punctations in irregular longitudinal rows near the median line, but scattered and smaller elsewhere, and one marked scrobiculation in the median line immediately above the suprabasal cleft, polar view irregularly oval, about two thicknesses in width, with three low swellings on each face, the edges of the lobes rounded or somewhat flattened, edge view of semicells rounded-conical, very slightly contracted above the sinus and markedly contracted toward the end L 110–117 μ, w 51–60 μ, th 24 μ, isth 13 μ Pools Stas : F 6, Great Barachois, F 8, Grandys Brook The type locality is Rose-au-Rue, also on the southern coast of Newfoundland, whence this plant was reported by Cushman (1904, 1907)

The original description took no cognizance of lateral suprasinuscidal swellings on the cell face, and designated the supraisthmial swelling as larger than in the present material, the punctulation of the wall is also newly reported

EUASTRUM AMPULLACEUM Ralfs (Pl XLII, Figs 2–3) — L 85–98 μ, w 52–62 μ, isth 13 μ Pools Stas 140, 146, Lookout Mt , F 8, Grandys Brook

EUASTRUM ANSATUM Ralfs (Pl XL, Fig 19) — L 115 μ, w 49 μ, th 36 μ, isth 13 μ Pool Sta B 26, Whitbourne

The Newfoundland plants are considerably longer and thicker than the Wests (1905) allow, but not dissimilar in proportions or surface features Wolle's figures (1892, Pl 28, Figs 8 10, Pl 33, Figs 11–12) can hardly represent the same thing, but without surface features it is hard to be sure In marginal contour they look more like what is here ascribed to *E didelta* because of distinctive surface characters Fremy (1930) shows a much smaller plant with narrow basal angles and a higher-placed lateral swelling

EUASTRUM BIDENTATUM Naeg (Pl XXXIX, Fig 10, Pl XL, Fig 13, Pl XLI, Fig 1) — L 43 60 μ, w 30–43 μ, isth 5 0–9 5 μ Ditches, pools, and wet slope Stas 135, Pointe Riche, 129, Doctors Hill, 102, McIvers Cove, B 26, Whitbourne

Some of the material, which was quite variable, showed tendencies toward rows of granules on the central protuberance instead of the rosette arrangements The specimen on Plate XLI, Figure 1, shows the strong scrobiculations just above the basal swelling, which the Wests (1896) find marked in their somewhat similar *E evolutum* The specimen illustrated in Plate XXXIX, Figure 10, is very like Boldt's *E elegans speciosum* (1888), which Nordstedt (1896) suggests may belong under *E bidentatum* It is possible that the writer has had a mixed group of species under observation

EUASTRUM BINALE (Turp) Ehrenb (Pl XL, Figs 1–3, 18) – L 17–20 μ, w 14–17 5 μ, isth 4 μ Pools Stas 130, Doctors Hill, 146, Lookout Mt , F 6, Great Barachois, F 8, Grandys Brook, B 26, Whitbourne

There was a good deal of variation in the width of the polar lobe and in the shape of the basal angle, such that forms like Figure 2 approach forma *hians* The central protuberance was often obscure, but could generally be confirmed (Fig 1)

EUASTRUM BINALE, near f HIANS W West (Pl XXXIX, Fig 3) — L 21 μ, w 15 5 μ, isth 3 5 μ Pool Sta B 26, Whitbourne

EUASTRUM BINALE var GUTWINSKII Schmidle (Pl XL, Fig 4) —

L 20–30 μ, w 15–21 μ, th 13 μ Ditches and pools Stas 102, McIvers Cove, F 6, Great Barachois, B 21, 28, Whitbourne

The basal angles of the form figured are unusually markedly tricrenate

EUASTRUM BOLDTII Schmidle, var ISTHMOCHONDRUM Grönblad, f (Pl XXXIX, Fig 4, Pl XLIII, Fig 3) — L 23 26 μ, w 18–21 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

This plant appears to differ from those of Grönblad (1921) in a greater prominence of the surface granules, notably those of the dorsal margin, in this resembling his drawings of the species, the granules on the species type are prominently figured and one or two granules are reported above the isthmus, but the Newfoundland plants are smaller than those of Schmidle (1896) The Wests (1896*b*) did not accept the species *Boldtii* as distinct from *E denticulatum* (Kirchn) Gay

EUASTRUM CORNUBIENSE W & G S West, f (Pl XL, Fig 8) — L 27 30 μ, w 17–21 μ, th 8 5 μ, isth 3 5 4 0 μ Pools Stas 112, St John Bay, 122, Pointe Riche

These plants on the basis of the face view might be referred elsewhere, but the circumscribed facial nodule differentiates them from forms of *E insulare* and the rounded oval form in polar view from forms of *E binale*, which is thinner toward the margins Borge's *Cosmarium venustum* var (1909) is also marginally thinner and has more sloping sides and less of an apical notch

EUASTRUM CRASSUM (De Bréb) Kg — Pools Stas F 6, Great Barachois, F 8, Grandys Brook

In part the wall was coarsely rather than finely punctate

EUASTRUM CRASSUM var SCROBICULATUM Lund (Pl XL, Fig 20, Pl XXIII, Fig 11) — L 140 150 μ, w 75 79 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

EUASTRUM CUNEATUM Jenner, var (Pl XL, Fig 21) — Specimens larger than usual, four or five pyrenoids to each semicell, wall thick, internally slightly pitted at the incrassate angles, surface punctulations obscure, ratio of length to breadth 2 07 1 L 141–156 μ, w 69–77 μ, w polar extremity 34 μ, isth 17 μ Pools and wet moss Stas F 6, Great Barachois, B 22, Whitbourne

Though this form is suggestive of Allorge's var *elongatum* (1930), there does not seem to be enough difference in relative dimensions, or in absolute size, to make a separate name necessary

Euastrum cuspidatum Wolle (Pl XLIII, Figs 1, 9) — Cell body small, about one third longer than broad, semicells three-lobed, the polar lobe obtusely cleft into slightly divergent segments, angular truncate, the lower and inner angles with one or two small spines, the upper angles each with one larger spine, interlobular incisions rounded subrectangular, sinus linear, slightly enlarged within, the basal angles rounded obtuse, the sides diverging slightly beyond the sinus, lower lobes with one stout spine outwardly directed at the upper or outer angle and two or three smaller spines above it, also a small spinule on the basal angle, face with an erose elevation in the median line about two fifths of the distance from the isthmus to the apex, and nodules or small spines near the basal and polar angles L 30–34 μ, l over spines 38 μ, w 24 μ, w with spines 30 μ, isth 4 5–5 0 μ Pool Sta F 8, Grandys Brook

In ascribing this Newfoundland material to Wolle's species (1884) the vagueness of his figure was discounted, but there is little doubt that the determination is correct As it is redescribed, recognition of the surface characters is especially important, and the figures emphasize minor features of contour quite neglected in the earlier descriptions The type locality is Absecon, New Jersey

Euastrum didelta (Turp) Ralfs (Pl XLII, Figs 1, 6) — L 81–140 μ, w 44–80 μ, th 28–45 μ, isth 10–14 μ Pools and ditches Stas 140, Lookout Mt , B 21, 26, 28, 29, Whitbourne

Some of the material showed more pronounced lateral sinuation than does Figure 6, but it intergraded with the type of Figure 1

Euastrum divaricatum Lund — Reported by Cushman (1907) from St Anthony

Euastrum doliiforme W & G S West, var (Pl XXXIX, Fig 7) — L 44 μ, w 28 μ, isth 7 5 μ Pool Sta 112, St John Bay

The apex of the Newfoundland form was more sloping and the sides were more indented than in the original, and it was nearly smooth

Euastrum elegans De Bréb (Pl XLIII, Fig 4) — L 28–29 μ, w 17-19 μ Pools Stas 119, Ingornechoix Bay, 146, Lookout Mt , 148, The Tableland, F 8, Grandys Brook

Euastrum elegans var ornatum W West (Pl XLIII, Figs — L 36–45 μ, w 22–24 μ, isth 4 5–4 7 μ Pools Stas

Ingornechoix Bay, 146, Lookout Mt , F 6, Great Barachois, F 8, Grandys Brook, B 26, Whitbourne

EUASTRUM FISSUM W West var AMERICANUM Cushm — Reported by Cushman (1907) from St Anthony

EUASTRUM GEMMATUM De Bréb (Pl XLIII, Fig 7) — L 40 μ, w 42 μ, th 26 μ, isth 13 μ, w polar lobe 21 μ, th polar lobe 18 μ Pools Stas B 21, 26, Whitbourne

EUASTRUM GIGANTEUM (Wood) Nordst var **latum**, var nov [5] (Pl XLI, Figs 8, 8a) — Cell very large, over two and one-half times as long as broad, semicells somewhat tapering, truncate, pole flattened, the cleft deep and closed, sides of semicells gently convex or with a faint undulation toward the base, basal angles acute or barely rounded, sinus closed, three strong rounded-conical projections near the base directed toward the isthmus, edge view of semicells slightly tapering, somewhat turgid above the base, contracted below the apex, poles rounded, the marginal angles, lateral and central projections all visible, membrane very thick, punctate, the punctations in irregular rows toward the center, becoming scattered laterally L 220 μ, w 80 μ, w poles 35–45 μ, th 66 μ, isth 28 μ Pool Sta F 6, Great Barachois

These distinctive plants are probably near *E giganteum* (Wood) Nordst , for that plant (Wood, 1873) has, as redescribed by the Wests (1896), a very similar morphology, though it is relatively narrower and thicker Since the figures of Wood and of Wolle (1884) are inconclusive, and, so far as they go, different from the Newfoundland plants, it seems best to segregate the present material *E brasiliense*, as described by Borge (1903) is a somewhat similar plant, but one much smaller and with a characteristically different contour

EUASTRUM HUMEROSUM Ralfs (Pl XLI, Fig 9) — L 124–160 μ,

[5] ***Euastrum giganteum* var latum, var nov — Cellula magna, 2½-plo longior quam crassior, semicellulis gradatim versus apicem angustatis, truncatis, polo planatis, alte fissuratis, fissura clausa, basi proiectionibus 3 validis rotundato-conicis versus isthmum directis ornatis, semicellulis aspectu aciali paulo angustatis lateribus paulo convexis vel prope basim subundulatis, angulis basalibus acutis vel vix rotundatis, sinu clauso, supra basim turgidiusculis, infra polos rotundatos contractis, angulis marginalibus etiamque proiectionibus lateralibus et centralibus omnibus visibilibus, membrana crassa, punctata, punctis versus centrum irregulariter lineariter ordinatis versus latera dispersis Long 220 μ, lat 80 μ, lat pol 35–45 μ, crass corp 66 μ, lat isth 28 μ Newfoundland, in loco dicto Great Barachois, legit *J M Fogg, Jr***

w 66–81 μ, th 47 μ, isth 15 μ Ditches Sta 102, McIvers Cove, possibly also at Sta 130, Doctors Hill

The surface swellings of the upper series seem rather near the isthmus in Figure 9 The plant was very rare in the Newfoundland material and no comprehensive idea of it could be had Borge (1906) shows as f *scrobiculata* a form rather like Figure 9, and (1930) material in outline rather like Plate XLII, Figure 8 Allorge's material (1930) referred to this species is also rather like the present, with minor differences

EUASTRUM INERME (Ralfs) Lund (Pl XL, Fig 10) — L 53–58 μ, w 32–40 μ, isth 8 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

EUASTRUM INSIGNE Hass (Pl XLII, Fig 5) — L 119–124 μ, w 58 μ, w polar lobe, 28 μ, th 30–36 μ, isth 13 μ Pools Stas F 6, Great Barachois, F 8, Grandys Brook

EUASTRUM INSIGNE Hass, f (Pl XLIII, Fig 8) — L 112–114 μ, w 59–61 μ, w polar lobes 28–31 μ, isth 13 μ Pools Stas 130, Doctors Hill, B 22, Whitbourne

This form differed from the typical material in the greater width of its parts and in the pitting The pitting was very coarse indeed, although shallow, and was general, or limited to the angles and midfacial area The neck was much broader than in the typical plant, and often broader than figured The lateral lobes were also higher and dorsally more undulate, and the sinusoidal mamillate projections broader The species is known to be variable

EUASTRUM INSULARE (Wittr) Roy (Pl XXXIX, Fig 5, Pl XL, Figs 5–6) — L 27–31 μ, w 17–22 μ, th 15 μ, isth 4–5 μ Pools Stas 112, 116, St John Bay, 119, Ingornechoix Bay, 125, Pointe Riche

This in part differs from the Wests' conception (1905) of the typical plant in that the polar lobe is less pronounced and the basal angles are more rounded (resembling their Pl 40, Fig 14), and even more from that of Johnson (1894) which, but for the lack of the facial papilla, has much resemblance to what the writer assigns to *E cornubiense*, f

EUASTRUM INTERMEDIUM Cleve var VALIDUM W & G S West (Pl XLII, Fig 4) — L 75–88 μ, w 41–54 μ, isth 6 5–7 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

EUASTRUM LAPPONICUM Schmidle (Pl XL, Fig 17) — L 42 μ, w 29 μ Pool Sta 146, Lookout Mt

Schmidle's figure (1898, Pl 2, Fig 29) shows a plant with angles less acute and with the central verrucae nearly divided into four, distinctly smaller (L 36 μ, w 24 μ) than the Newfoundland plants These are also a little longer than the plant known to Gronblad (1921, 38 μ) and are without certain of the minor granules (particularly those immediately above the basal angles), but are otherwise in good agreement

EUASTRUM MONTANUM W & G S West (Pl XXXIX, Fig 2) — L 18–22 μ, w 15–16 5 μ, isth 4 μ Pool Sta 130, Doctors Hill

In the initial survey this plant (somewhat small for the designated species) was not adequately distinguished from *E binale Gutwinskii*, from which it appears (by the Wests' figures and data) to differ in a relatively wider and shorter apical lobe The cell width in *E montanum* is about 1 50 to 1 33 times the width of the polar lobe, whereas in *E binale Gutwinskii* the cell width should be 1 60 times the width of the polar lobe, in addition to the other differences

EUASTRUM OBESUM Josh — Reported by Cushman (1907) from St Anthony

EUASTRUM OBLONGUM (Grev) Ralfs (Pl XLI, Fig 7, Pl XLII, Fig 8 (f), 10) — L 125 149 μ, w 63–75 μ, th 48 μ, isth 19 μ Pools Stas 148, The Tableland, B 21, Whitbourne

The specimen represented by Figure 8 approaches var *depauperatum* W & G S West

EUASTRUM OBLONGUM var CEPHALOPHORUM W West — Reported by Cushman (1907) from Bay of Islands

EUASTRUM PECTINATUM De Bréb var BRACHYLOBUM Wittr, f **majus**, f nov* (Pl XL, Fig 16) — Differing from the variety in its greater size and in having the protuberances of the upper angles of the lateral lobes submarginal, the polar lobe more elongate, its end angularly low-rounded, broadly retuse, with angles submarginally protuberant L 77–84 μ, w 48–56 μ, th 36–40 μ, isth 10 μ Pools Stas 135, Pointe Riche, B 26, Whitbourne

* *Euastrum pectinatum* var *brachylobum* f **majus**, f nov — A varietate differt magnitudine grandiore et submarginalibus angulorum superiorum loborum lateralium protuberationibus, *lobo polari plus elongato apice angulatim depresso* late retuso, angulis paulum proiectis Long 77–84 μ, lat 48–56 μ, crass corp 36–40 μ, lat isth 10 μ Newfoundland, in loco dicto Whitbourne, legit Belle Burr

EUASTRUM PECTINATUM var BRACHYLOBUM f **rostratum,** f nov [7] (Pl XLI, Fig 4) — Differing from the variety in having the sides of the lateral lobes sloping toward the sinus, the lower angles of the lateral lobes rostrate in the median lateral line, the protuberances of the upper angles of the lateral lobes obsolete, the polar lobe narrower, and the interlobular angles more rounded-obtuse, with the angles submarginally protuberant L 70 μ, w 52 μ, w polar lobe 22 μ, th 32 μ, isth 12 μ Pool Sta 135, Pointe Riche

EUASTRUM PECTINATUM var INEVOLUTUM W & G S West (Pl XL, Fig 15) — L 60 μ, w 36 μ, th 29 μ, isth 6 5 μ Pools Stas 122, 135, Pointe Riche, 119, Ingornechoix Bay, 140, Lookout Mt

A form very close to the Wests' conception except that the lateral protuberances of the polar lobe are somewhat confluent with the crest and that in some specimens the polar lobe is decidedly longer in relation to breadth

EUASTRUM PECTINATUM var **reductum,** var nov [8] (Pl XL, Fig 14) — Cells of moderate size, about one half longer than wide, semicells three-lobed, the interlobular angle rounded-obtuse, sides of the polar lobe sloping slightly toward the sinus at the surface, but sloping slightly from it in the median lateral line, sinus acute, closed within, surface protuberances reduced to one low, broad, supramedian swelling, polar view showing the polar lobe as rectangular with turgid sides, the facial swelling as broad and low, the lateral lobes with three slight swellings on the ends,

[7] *Euastrum pectinatum* var *brachylobum* f **rostratum,** f nov — A varietate differt marginibus *facialibus* loborum lateralium ad sinum angustatis et angulis inferioribus loborum lateralium in lineam aciei mediam rostratis, protuberationibus *angulorum superiorum loborum lateralium obsoletis,* lobis *polaribus* angustioribus angulis sensim proiectis et angulis interlobatis obvie rotundiuscule obtusis Long 70 μ, lat 52 μ, lat lob pol 22 μ, crass corp 32 μ, lat. isth 12 μ. Newfoundland, in loco dicto Pointe Riche, legit Bayard Long

[8] *Euastrum pectinatum* var reductum, var nov — Cellulae mediocres, dimidio longiores quam latiores, semicellulis trilobatis, angulis interlobatis rotunde obtusis, lateribus lobi polaris superficialiter sensim versus sinum obliquatis sed lateraliter (in linea media laterali) versus apicem obliquatis, sinu lineari, extus dilatato, superficiei protuberatione una sola depressa, lata supramediali, semicellulis aspectu polari exhibentibus lobum polarem rotunde rectangulum, protuberationem latam depressamque, et lobos laterales apice gibbositatibus 3 depressis ornatos, membrana vel fere laevi vel evidenter et dense punctata, somatibus pyrenoideis in semicellula singulis Long 50–70 μ, lat 35–44 μ, crass corp 22–28 μ, lat isth 8 5–11 5 μ. Newfoundland, in loco dicto Pointe Riche, legit Bayard Long

membrane nearly smooth to clearly and closely punctate, pyrenoid single in each semicell L 50 70 μ, w 35–44 μ, th 22–28 μ, isth 8 5–11 5 μ Pools Stas 122, (type) Pointe Riche, 148, The Tableland

This variety differs from the species in limitation of surface protuberances to the central one in the slightly different shape of the polar lobe and the increased punctation of the wall of some individuals No intergrading with the type was observed Boldt's var *lagenale* (1888) shows surface protuberances lacking in the present variety, and is particularly different when viewed from the edge of the cell

EUASTRUM PICTUM Børg var SUBRECTANGULARE W & G S West, f (Pl XL, Fig 12) — L 70 μ, w 52 μ, isth 8 5 μ Pond Sta 116, St John Bay

Difficult to place, this form shows much in common with the variety designated, and recalls the Wests' note (1905) upon a connecting form with *E bidentatum*

EUASTRUM PINGUE Elfv (Pl XXXIX, Fig 9) — L 58 μ, w 40 μ, isth 17 3 μ Pool Sta 146, Lookout Mt

EUASTRUM PINNATUM Ralfs (Pl XLI, Fig 2) — L 136 μ, w 72 μ, isth 21 μ Pool Sta 146, Lookout Mt

EUASTRUM PINNATUM, f (Pl XLI, Fig 6) — Cell large, more than twice as long as broad, semicell five-lobed, the polar lobe wide and flattened, slightly concave on each side of the linear polar cleft, ends rounded-acute, the upper interlobular incision rounded-acute, the upper margins transverse, lower sloping (the widest region of the cell), lower lateral lobes rounded-acute, sloping from the closed sinus to the broad obtuse-rounded angular lower interlobular incisions, surface protuberances large, rounded-conical, three on each face, one median directed toward the isthmus, two lateral, outwardly and upwardly directed, extending slightly beyond the upper side of the lower lateral lobe, end view showing the polar lobe deeply rounded-cleft in the midlateral line, slightly thicker toward the edge than toward the incision, upper lateral lobes deeply and more acutely rounded-cleft in the midlateral line, lower lateral lobes not cleft, but somewhat rounded-acute toward the margin, the middle protuberance rounded from above, the lateral protuberances (which would make the lower lobe appear somewhat three-lobulate from

above) obscured by the upper lateral lobes, edge view subrectangular, somewhat tapering from the base but dilated at the apex, membrane smooth to slightly punctate-erose at the thickened angles L 160 μ, w polar lobe 53 μ, w upper lateral lobes 77 μ, w basal lobes 75 μ, th 50 μ, isth 25 μ Pool Sta F 8, Grandys Brook

This plant differs from *E pinnatum* in that the lower lateral lobe is not retuse-rectangular in face view, but slopes sharply from the sinus, and instead of low erect swellings the lobe bears large conical projections which extend obliquely beyond the upper margin The absence of the two upper median swellings may be distinctive, as is also the greater relative width of the upper lateral lobes From *E multilobatum* Wood (1873) it is distinguished (if his drawing is correct) by the presence of a polar incision and by the basal protuberances, as well as the shape of the lateral lobes, however, the accuracy of his observations may well be questioned, and he also may have had *E pinnatum* under observation With the chloroplasts intact, a very slight rotation of the cell on the longitudinal axis would have obscured the polar cleft

Euastrum pulchellum De Bréb var retusum W & G S West, f (?) (Pl XXXIX, Fig 6, Pl XLIII, Fig 2) — L 32–34 μ, w 24–28 μ Pools Sta 140, Lookout Mt

The apical lobe is rather wider than in *E pulchellum*, and the arrangement of the granules on the central protuberance is different, however, the variation in the material was considerable In spite of these features and the small size the writer is inclined to consider this material related to *E pulchellum*, with suggestive resemblances to the variety named

Euastrum sinuosum Lenorm var reductum W & G S West, f (?) (Pl XL, Fig 9) — L 65 μ, w 40–42 μ, isth 12 μ Pool Sta 146, Lookout Mt

The Wests (1905) do not mention the presence of small scrobiculations between the swellings in their form of this plant, but these were quite distinct in the Newfoundland specimens

Euastrum subhexalobum W & G S West (Pl XL, Fig 11) — L 40 μ, w 24 μ Pool Sta 146, Lookout Mt

Very rare and incompletely studied See Wests' paper (1898), p 287

EUASTRUM TUDDALENSE Strøm var **novae-terrae**, var nov [9] (Pl XLI, Fig 3) — Cells very small, about one fourth longer than broad, semicells three-lobed, the polar lobe twice as large as the lateral lobes, with an open apical notch and small apiculi at the outer angles, interlobular incisions somewhat rounded, nearly rectangular, lateral lobes somewhat squared, slightly retuse, angular at the margin, surface with nodules or apiculi midway of the ends of the polar lobes on each face below the outer polar angle, and below the upper angle of the lateral lobes, also a large round-incrassate and flattened protuberance near the center of each semicell, in polar view the lateral margins of the polar and lateral lobes crenate-granulate, the midlateral protuberance prominent L 19 μ, w 15 μ, th 12 2 μ over protuberance, 7 μ without protuberance, isth 4 5 μ Pool Sta F 8, Grandys Brook

Borge (1930) describes a form of this species which, except for the midfacial protuberances, has vague surface details

EUASTRUM TURNERI W West, f (Pl XXXIX, Fig 8) — L 44 μ, w 30 μ, isth 9 μ Pool Sta B 26, Whitbourne

This material differs from the Wests' figures (1905) in having a coarser granulation on the central protuberance and somewhat fewer granules over the rest of the cell surface

EUASTRUM VALIDUM W & G S West (Pl XL, Fig 7) — L 27 μ, w 20 μ, isth 3 μ Pool Sta 146, Lookout Mt

EUASTRUM VENTRICOSUM Lund (Pl XLII, Fig 9, Pl XLIII, Fig 10) — L 107–173 μ, w 65–103 μ, isth 17–21 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

EUASTRUM VERRUCOSUM Ehrenb (Pl XLIII, Fig 12) — L 95 μ, w 77 μ, isth 17 μ Pool Sta B 21, Whitbourne

EUASTRUM WOLLEI Lagerh, var (Pl XLII, Fig 7) — Cell large, about one half longer than wide, semicells somewhat truncate-

[9] *Euastrum tuddalense* var **novae-terrae**, var nov — Cellulae minimae quarta longiores quam latiores, semicellulis trilobatis, lobo polari duplo grandiori quam lateralibus, apice aperte emarginatis, ad angulos exterioribus apiculatis, vallicul s interlobatis subrotundis, fere rectangulis, lobis lateralibus subrectangulis, paulum retusis, angulis truncatis, superficie utrinque prope apices loborum polarium et infra angulum superiorum loborum lateralium nodulosa vel apiculata, etiam cum rotundata incrassata depressa protuberatione prope semicellulae centrum praedita, semicellulis aspectu polari exhibentibus margines laterales *crenate granulatas loborum polarium* et lateralium et gibbositatem midlateralem prominentem Long 19 μ, lat 15 μ, crass corp 12 2 μ, lat isth 4 5 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

pyramidate, with dilated apex, apical lobe broad, rounded, slightly concave on each side of the narrow apical cleft, sides below the apical lobe sharply contracted to a rounded interlobular incision, sides below this incision straight or slightly undulate to the acute ends of the lateral lobes, sinus closed within, becoming open laterally by reason of the curved form of the lower margin of the semicells, surface with two large rounded protuberances on the face about one third of the distance from the isthmus, membrane heavy, incrassate at the angles, deeply pitted, especially at the angles, pits in somewhat longitudinal rows near the upper center of each semicell, otherwise as in the species L 180 μ, w 120 μ, w polar lobe 62 μ, w subpolar neck 43 μ, isth 30 μ Pool Sta 146, Lookout Mt

The sinus narrowed midway and closed within, the sharp lateral lobes, broad polar lobe and isthmus, two facial tumors, and a length of one and one-half times the width are characters not conjoined in the published forms of this desmid, but since only a few individuals were seen no special designation is given

TETMEMORUS Ralfs

TETMEMORUS BREBISSONII (Menegh) Ralfs (Pl XLIII, Figs 16–17) — L 205 220 μ, w 41 43 μ, wall with longitudinally elongate and seriate punctae Pools Stas 130 Doctors Hill, F 8, Grandys Brook, B 27, Whitbourne

TETMEMORUS BREBISSONII var MINIMUM W & G S West — Reported by Cushman (1908) from Rose-au-Rue

TETMEMORUS BREBISSONII var MINOR De Bary (Pl XLIII, Fig 15) — L 65 μ, w 15–17 μ Pools Stas 130 Doctors Hill, 146, Lookout Mt , F 6, Great Barachois, F 8, Grandys Brook

TETMEMORUS BREBISSONII var TURGIDUS Ralfs — Reported from Rose-au-Rue by Cushman (1907)

TETMEMORUS GRANULATUS (De Bréb) Ralfs (Pl XLIII, Fig 18) — L 240 μ, w 28 μ Pools Stas 140, Lookout Mt , F 6, Great Barachois, F 8, Grandys Brook

TETMEMORUS GRANULATUS var ATTENUATUS W. West (Pl XLIII, Fig 13) — L 150 μ, w max 30 μ, w tips 17 μ, isth 26 μ Ditch Sta B 28, Whitbourne

TETMEMORUS LAEVIS (Kg) Ralfs (Pl XXXIX, Fig 11, Pl XLIII, Fig 14) — L 70–120 μ, w 18–24 μ Dripping slopes, ditches,

and pools Stas 129 (frequent), Doctors Hill, 145 (frequent), Lookout Mt, 102 (frequent), McIvers Cove, F 8, Grandys Brook, B 22, 24, 28, Whitbourne

MICRASTERIAS C Agardh

MICRASTERIAS AMERICANA (Ehrenb) Ralfs (Pl XLV, Fig 5) — L 150 μ, w 120 μ, isth 24 μ Pool Sta 119, Ingornechoix Bay

MICRASTERIAS APICULATA (Ehrenb) Menegh - L 124 μ, w 128 μ, w base polar lobe 26 μ, w apex polar lobe 37 μ, isth 21 μ Rills Sta 136, Eddys Cove

MICRASTERIAS APICULATA, near var BRACHYPTERA (Lund) W & G S West (Pl XLV, Fig 6) — Cell of moderate size, semicell depressed-semicircular the polar lobe as long as broad, projecting beyond the general contour, contracted below the apex but otherwise with subparallel sides, apex retuse, angles bimucronate, face bimammillate near the apex, lateral lobes about thrice successively divided, each lobule bimucronate, the lobes not closely proximate, but incisions much narrower than the lobes, surface showing two spines on each lateral sinusoidal margin, membrane very obscurely punctulate L 138 μ, w 136 μ, w and l polar lobe 42 μ Pool Sta 135, Pointe Riche

Since this was seen in but few individuals, no idea of its variation can be given It is too large and has a too broad-based polar lobe for var *varvicensis* Turn, which it slightly resembles It differs from the true form of var *brachyptera* in having a shorter polar lobe, a reduced armature of spines, and more dissected lateral lobes

MICRASTERIAS APICULATA var FIMBRIATA (Ralfs) Nordst (Pl XLVIII, Fig 7) — L 236 μ, w 206 μ, w shaft polar lobe 38 μ, end 46 μ, isth 25 μ Pool Sta 119, Ingornechoix Bay

The Newfoundland specimens show somewhat shorter spines and a more projecting polar lobe than is usual The width of the polar lobe differentiates this plant from *M papillifera* var *glabra* Nordst, which it slightly resembles

MICRASTERIAS ARCUATA Bailey (Pl XLIV, Fig 6) — L 93-102 μ, w 94-103 μ, isth 12 μ Pool Sta F 8 (frequent), Grandys Brook

This very interesting species was reported by Taylor and Fogg (1927) Although there is considerable variation, the size range was not great, and all the material should be associated with the

original species of Bailey (1851) and not with var *gracilis* Turner (1893), which is nearly 50 per cent broader than long and has more slender lobes The average width of several Newfoundland specimens was 95 μ, except one individual which reached 103 μ, and the average length was 97 μ It should be noted that the arms do not taper gradually throughout, but though slender are obtusely rounded and distinctly aculeate See also the notes on *M expansa*

MICRASTERIAS CONFERTA Lund (Pl XLVI, Fig 3) — L 109–122 μ, w 96–107 μ, isth 15–17 μ Pools Stas 146 (frequent), Lookout Mt, B 28, Whitbourne

MICRASTERIAS CONFERTA var NOVAE-TERRAE Cushman (Pl XLV, Fig 3, Pl XLVIII, Fig 1) — L 113–150 μ, w 96–113 μ, w polar lobe apex 35–47 μ, base 16–21 μ Pools Stas 145 (frequent), Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook

The association of Cushman's variety (1904) with *M conferta* is not convincing to the present author The form resembles rather Wolle's *M speciosa* (1896), differing in a marked broadening of the polar lobe and increased breadth of the lateral lobe segments The specimen illustrated on Plate XLVIII does not quite reach Cushman's type in the width of the end of the polar lobe and has a somewhat narrower sinus, but agrees otherwise, and many plants agreed in all respects The wall was granulate in most specimens, but perhaps this was not normal, on quite smooth individuals a few spines appear near the lateral margins of the polar lobe and the adjacent lateral lobes

A very curious feature of the material from Station 145 was the fact that the cells were in part heavily coated with a brownish granulate crust, supposedly an iron compound This also occurred on some of the material of *M conferta*, *M foliacea*, and *M radiosa* At Station 145 the cells were sometimes deformed by the distortion of the spines, obliteration of surface characters, and reduction of marginal incisions This malformation appeared to affect certain species in a sample only, leaving most of the plants in good condition The appearance was close to that figured (*M papillifera verrucosa*) by Schmidle (1896)

MICRASTERIAS DENTICULATA De Bréb — Reported by Cushman (1907) from Bay of Islands

MICRASTERIAS EXPANSA Bailey (Pl XLIV, Fig 4, Pl XLVII,

Fig 1) — L 56–105 μ, w 47–103 μ, isth 9–13 μ Pools Stas 140, 146, Lookout Mt, F 6 (frequent), Great Barachois, F 8 (frequent), Grandys Brook

A very interesting alga reported by Taylor and Fogg (1927) The size range was very marked, but individuals over 80 μ long were scarce The average length was 73 5 μ, width 70 4 μ, isthmus 11 μ In the larger individuals a slight resemblance to *M arcuata* occurs, but the present species has the basal lobes somewhat inflated below, and strictly divergent, with the upper sides straight rather than upcurved, the polar lobe is also relatively narrower at the apex It is to be noted that the ends of the arms are rounded and aculeate, for in Bailey's paper (1851) they are simply described as acute, in characteristic individuals the apical depression in the polar lobe is seen to be distinctly roughened The polar lobes in one individual were triradiate Borge (1918) follows Nordstedt in assigning his plants to *M arcuata* as a variety, but this does not appeal to the present writer as an adequate recognition of the differences between the types Borge's Brazilian specimens were smaller and somewhat simpler in contour than the northern individuals, and several variants not represented in Newfoundland are distinguished

MICRASTERIAS FOLIACEA Bailey (Pl XLIV, Fig 3) — L 65–69 μ, w 86 μ Pools Stas 140, 146, Lookout Mt

According to Donat (1931), this plant appears to have a relatively southern (and especially south Asian) distribution, so that this record is a rather isolated one

MICRASTERIAS JENNERI Ralfs, near var SIMPLEX W West (Pl XLIV, Fig 2, Pl XLV, Fig 4) — L 160–170 μ, w 109–117 μ, isth 19–22 μ Pools and ditch Stas F 6, Great Barachois, F 8, Grandys Brook, B 28, Whitbourne

These specimens differ from the variety in their slightly greater size and more deeply retuse lateral lobes, but Grönblad records deeper indentations in this plant than do the Wests.

MICRASTERIAS JOHNSONII W & G S West var **bipapillata**, var nov [10] (Pl XLVIII, Fig 5) — Similar to the species, but differing

[10] *Micrasterias Johnsonii* var bipapillata, var nov — Formae typicae similis sed varietas differt spinis terminalibus brevioribus in lobos laterales et defectu spinarum in loborum superficiebus, proiectionibus 2 subaculeatis mamillatis utrinque versus apicem lobi terminalis, et magnitudine minore Long 250 μ, lat. 240 μ Newfoundland, in loco dicto Lookout Mt, legit Bayard Long

in having shorter terminal spines on the lateral lobes, no spines on the margins of the lobe faces, in having two mammillate-subaculeate projections on each side of the terminal lobe near the top, and in being slightly smaller L 250 μ, w 240 μ Pool Sta 140, Lookout Mt

MICRASTERIAS OSCITANS Ralfs (Pl XLIV, Fig 7, Pl XLVIII, Fig 8) — L 150 μ, w 145–148 μ, th 60 μ Pools Stas F 6, Great Barachois, F 8, Grandys Brook

The Wests (1905) mention observations to the effect that American representatives are wider than British, these plants confirm their statement

MICRASTERIAS PAPILLIFERA De Bréb (Pl XLVI, Fig 4) — L 156 μ, w 141 μ, isth 21 μ Pools Stas 145, Lookout Mt, B 21, Whitbourne

The spines bordering the incisions were very pronounced in at least part of the material On the lower half of the specimen illustrated the marginal spines were twinned at right angles to the frontal plane

MICRASTERIAS PAPILLIFERA, f (Pl XLVI, Fig 2) — L 150 μ, w 135 μ, isth 18 μ Pool Sta F 8, Grandys Brook

Reduced facial spines and a close approximation of the lateral lobes, with a rather broad and rounded polar lobe, make this form uncertain of assignment

MICRASTERIAS PAPILLIFERA var GLABRA Nordst, f (Pl XLVI, Fig 1) — L 160 μ, w 130 μ Pool Sta 146, Lookout Mt

MICRASTERIAS PINNATIFIDA (Kg) Ralfs (Pl XLIV, Fig 5) — L 65 μ, w 67 μ Pools, rills, and wet rocks Stas 119, Ingornechoix Bay, 122, 135, Pointe Riche, 140, Lookout Mt

MICRASTERIAS RADIATA Hass (Pl XLV, Fig 1) — L 197 μ, l polar axis 132 μ, w 170 μ, w base polar lobe 23 μ, isth 19 μ Pool Sta 140, Lookout Mt

MICRASTERIAS RADIATA Hass var GRACILLIMA G M Smith (Pl XLIV, Fig 1) — L 177–190 μ, w 160–170 μ, isth 15 μ Pool Sta 146, Lookout Mt

MICRASTERIAS RADIOSA Ralfs, f (Pl XLVIII, Fig 6) — L 173 μ, w 165 μ In wet moss Sta B 6, St Johns

Somewhat anomalous in its short polar lobe, so that it suggests *M papillifera glabra*, this material because of its well-separated

lateral lobes and resemblance to Smith's figure (1924, p 46) is tentatively associated with *M radiosa*

MICRASTERIAS RADIOSA var ORNATA Nordst (Pl XLVIII, Fig 4) — L 210 μ, w 201 μ, w base of polar lobe, 22 μ, top 38 μ Pools Stas 148, The Tableland, B 21, Whitbourne

MICRASTERIAS RADIOSA var ORNATA f ELEGANTIOR G S West (Pl XLV, Fig 2, Pl XLVIII, Fig 3) — L 194 μ, w 194 μ Pool Sta 140, Lookout Mt

There was a tendency toward suppression of the facial spines in this material, and the marginal aculei were often absent

MICRASTERIAS SPECIOSA Wolle, f (Pl XLVIII, Fig 2) - L 114 μ, w 116 μ, isth 10 μ Pools Stas F 6, Great Barachois, F 8 Grandys Brook

According to Wolle's figures (1892) there is considerable variation in the length of the polar lobe The writer's material approximates the shorter habit, the angle formed by the lower sides of the expanded polar lobe is more acute in the Newfoundland material

MICRASTERIAS THOMASIANA Archer, var (Pl XLV, Fig 7) — Cell large, somewhat longer than broad, polar lobe hardly one fifth longer than breadth at apex, sides slightly concave from rounded apical angles, end concave with an abrupt rounded median cleft and two slight swellings on each face, lateral lobes cleft four times successively, the ultimate lobes retuse, angles rounded or barely acute, face of semicell near isthmus bearing three large projections directed toward the isthmus, the lateral mammillate, the central three-lobed, the middle lobe broadly truncate, wall thin, minutely punctulate L 226 μ, w 188 μ, l polar lobe 73 μ, w 65 μ, base 30 μ, isth 26 μ Pool Sta F 6, Great Barachois

This differs from *M Thomasiana* in the reduced elaboration of the cell, especially of the basal projections, and the angle at which the projections are presented The Wests (1905) describe a greatly simplified form with basal projections almost eliminated, but in the present plant these differ in size and position from the form of the Wests'

MICRASTERIAS TRIANGULARIS Wolle (Pl XLV, Fig 8) — L 215 μ, w 178 μ, w polar lobe apex 113 μ, base 75 μ, l lobe 38 μ, isth 30 μ Pool Sta F 6, Great Barachois

This material is not much larger than that of Wolle's citation

(1884), and since the contours seem about intermediate between his two figures, his name is tentatively adopted for the Newfoundland plants

MICRASTERIAS TRUNCATA (Corda) De Bréb (Pl XLVI, Fig 5) — L 101–110 μ, w 95–108 μ, isth 18–21 μ Pools Stas 130, Doctors Hill, 146, Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook, B 22, 28 (common) Whitbourne

Variable, but since G S West (1899) has treated this variability at length no special figures are given Associated but never intergrading with the following variety

MICRASTERIAS TRUNCATA var **turgida,** var nov [11] (Pl XLVI, Figs 6–8, Pl XLVII, Figs 2–3) — Cells very slightly longer than broad, polar lobe broad, in length occupying about two fifths of the length of the semicell, with a curved dorsal margin bearing one or two strong spines near the lateral angles, lateral lobes simpler than usual in this species, once narrowly and shallowly cleft, with single strong spines at the angles, polar incisions and isthmial sinus nearly closed, polar view diamond-shaped, thick and rounded at the center, tapering directly to the acute margins, the ratio of thickness to width about 4 7, in edge view the semicells subcircular, centrally somewhat inflated L 60–72 μ, w 62–79 μ, th 42 μ, isth 11–15 μ Pools Stas 146, Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook, B 26, 27, 28 (very abundant, the type station), Whitbourne [12]

SPONDYLOSIUM De Bréb

SPONDYLOSIUM PLANUM (Wolle) W & G S West (Pl XLIX, Fig 7) — L 9 5–16 μ, w 11 5–17 μ Pools and stream Stas 116, St John Bay, 140, Lookout Mt, B 24, Whitbourne

[11] *Micrasterias truncata* var **turgida,** var nov — Cellulae vix longiores quam latiores, lobo polari lato, longitudine minus quam semicellulae dimidio, margine dorsali spinis 1 vel 2 validis prope angulos laterales praedito, lobis lateralibus quam in forma speciei typica simplicioribus, anguste parumque bifidis, spinis singulis validis in angulis praeditis, incisionibus polaribus et sinu isthmiaco fere clausis, cellula aspectu polari rhombea, centro incrassata rotundata, a linea recta ad margines acutas obliquata, crassitudine plus quam latitudinis dimidio, semicellulis aspectu aciali suborbicularibus lateraliter ad medium subinflatis Long 60-72 μ, lat 62–72 μ, crass corp 42 μ, lat isth 11–15 μ Newfoundland, in loco dicto Whitbourne, legit Belle Burr

[12] The writer is greatly indebted to Dr Rolf Grönblad for advice regarding the disposition of this material

The sinus was less open in the material from St John Bay than in that from the other stations

SPONDYLOSIUM PULCHRUM (Bail) Arch (Pl XLIX, Fig 8) — Cells moderately large, in compressed filaments, semicells broadly oval, the polar area slightly elevated and flat, the lateral angles obliquely truncate on the upper side, the sinus deep, slightly open but acute within, from polar view the cells expanded on each side of the central region, the expanded portion broadest at the middle, slightly truncate on the distal lateral faces, rounded at the extremities, from edge view the semicells asymmetrically oval, more convex toward the acute open isthmus, more compressed toward the pole, membrane thin, minutely punctulate L 40 μ, w 85 μ, w at poles 22 μ, th, 12 μ, th lateral lobes 28 μ Pools Stas 112, St John Bay, 140 (frequent), Lookout Mt

Though no question arises as to the species to which these plants should be referred, the varietal assignment is not so easy If Wolle's var *inflatum* is identical with the type, this plant differs only in a somewhat more median position of the greatest thickness of the lateral lobes, compared with Smith's figures (1924) the Newfoundland plants have wider and lower polar elevations and in polar view approach more closely to Borge's var *brasiliense* (1918), the chief difference being that his plants show a sinus even more linear within

SPHAEROZOSMA Corda

SPHAEROZOSMA AUBERTIANA W West (Pl XLIX, Fig 9) — Cells small, forming long, compressed filaments, approximated at the poles and showing clasping projections close to the median line, semicells depressed-oval, the top faintly produced and flattened, with two small projections obliquely placed on opposite faces, the later angles of the semicells slightly depressed, sinus open, acutely rounded within, membrane showing two incurved rows of distinct plugged pores, the rows regular and pores well spaced L 21–23 μ, w 28–32 μ, isth 7–8 μ Pool Sta B 21, Whitbourne

The distinctions between this material, *S Aubertiana Archeri* (Gutw) W & G S West and *S vertebratum punctulatum*, seem difficult to indicate According to Carter (1923), the latter plant has several rows of granules, as illustrated, Grönblad (1920,

1921) illustrates forms with two rows Carter emphasizes the relative length in establishing the distinction, which by the mean of her measurements is 1 1 27 for *S vertebratum punctulatum* and 1 1 5 for *S Aubertiana Archeri*, whereas Smith (1924) gives data for a ratio of 1 1 73 in his plants The Carter illustrations hardly agree with the text, for the ratio as taken from them is close to 1 1, approaching in but one case to 1 1 5 The present material shows a ratio of 1 1 36, perhaps nearer to *S vertebratum punctulatum*, but the large and clear pores in two well-spaced rows and the greater cell size induce the writer to retain the material in *S Aubertiana*, particularly in view of the large size of Smith's plants and Grönblad's discard of var *Archeri* (1931)

SPHAEROZOSMA EXCAVATUM Ralfs — Reported by Cushman (1907) from St Anthony

SPHAEROZOSMA GRANULATUM Roy & Biss, var — Cells very small, forming long, compressed filaments, approximated at the poles, the clasping projections not evident, semicells obconical, rounded at the lateral angles, the sinus open and rounded, membrane bearing granules near the angles and on the margin, about six in evidence on each side of each semicell L 15 μ, w 11-13 μ, isth 5 5 μ Pool Sta B 21, Whitbourne

This plant differs considerably in size and in the more open sinus from those of Carter's figures and data (1923, l 8-9 μ, w 8–10 μ, isth 4-5 μ)

DESMIDIUM C Agardh

DESMIDIUM AEQUALE W & G S West (Pl XXXIV, Fig 13) — L 20–22 μ, w 30–35 μ, th 28–30 μ Pools Stas 146, Lookout Mt, F 6, Great Barachois

This material was not readily distinguishable from *D quadratum* in size, since both exceeded the specifications of the Wests (1896) The extreme forms are segregated under the two names

DESMIDIUM APTOGONUM De Bréb var ACUTIUS Nordst (Pl XLIX, Fig 2) — L 22 μ, w 40 μ Pools and rills Stas 140, 146, Lookout Mt (frequent), F 6, Great Barachois, F 8, Grandys Brook, B 21, Whitbourne

DESMIDIUM APTOGONUM var ovale, var nov [13] (Pl XLIX, Fig 3) —

[13] *Desmidium Aptogonum* var **ovale**, var nov — Cellulae filamenta longa formantes, compressis, a latere visae transverse subrectangulae, area polari (inter

Cells forming long filaments, individual cells compressed, transversely subrectangular in side view, the polar area concave between the two truncate attaching arms, sinus broadly open, acute, polar view oval, the sides somewhat compressed, convex to nearly flat, attaching arms broadly pyriform in polar view, cell membrane punctulate toward the poles L 18-21 μ, w 31 34 μ, th 17 μ Pools Stas 112, St John Bay, 119, Ingornechoix Bay, 148, The Tableland

This plant is obviously to be compared with *D Aptogonum Ehrenbergii* As Delponte (1873), the Wests (1896), and Carter (1923, Pl 164, Fig 5, possibly not Fig 4) illustrate that plant, the sides are markedly concave in polar view, and the proportions in side view differ from those of the Newfoundland individuals Borge (1907) described a *D Aptogonum* f which closely resembles this, though it is perhaps smaller

DESMIDIUM BAILEYI (Ralfs) Nordst (Pl XLIX, Fig 1) — L 28 μ, w 28 μ Pools Stas 146, Lookout Mt, F 6 (frequent), Great Barachois

DESMIDIUM COARCTATUM Nordst — Reported by Cushman (1907) from St Anthony

DESMIDIUM GRACILICEPS (Nordst) Lagerh, f - L 32 38 μ, w 56 μ, w apex 20 25 μ, th 40 μ Pool Sta F 6, Great Barachois

The cells of this material have a broad apex, and therefore present an aspect quite different from those of the next form The difference is suggestive of a transition to *D Grevillii* The ratio of length to breadth is about 0 65 1 0

DESMIDIUM GRACILICEPS f MAJUS Lagerh (Pl XXXIV, Fig 15) — L 42-44 μ, w 50-56 μ, w apex 17-20 μ, th 38-40 μ Pool Sta 140, Lookout Mt

The type material came from Massachusetts, this material is close to Lagerheim's dimensions and figure (1896) The ratio of length to breadth is about 0 83 to 1 0

DESMIDIUM GREVILLII (Kg) De Bary (Pl XXXIV, Fig 11, Pl XLIX, Figs 4-5) — L 22-26 μ, w 60-63 μ, th 40 μ Pools

bracchia) 2 truncata cohaerentia, concava, sinu late aperto, cellulae aspectu polari lateribus subcompressis, convexis vel fere planis, bracchiis cohaerentibus late pyriformibus, membrana versus polos punctulata Long 18-21 μ lat 31 34 μ, crass corp 17 μ Newfoundland, in loco dicto Ingornechoix Bay, legit Bayard Long

Stas F 6, Great Barachois, 140 (major element), 146, Lookout Mt

The figures of Plate XLIX show exceptionally long cells, the ratio being about 0 5 to 1 0 The filaments were much wider than those of the Wisconsin representatives (Smith, 1924) The material at Station 140 was generally of shorter cells, with the ratio of length to breadth 0 38 to 1 0 According to Borge (1925, Pl 6, Figs 13–15) relatively long cells occur in this species

DESMIDIUM QUADRATUM Nordst (Pl XLIX, Fig 6) — L 19–22 μ, w 28–29 μ, th 22–24 μ Pools Stas 146, Lookout Mt , F8, Grandys Brook

DESMIDIUM QUADRATUM var **doliiforme**, var nov [14] (Pl XXXIV, Fig 14) — Cells forming long filaments, individual cells tapered-cylindrical, about one half longer than broad, with a slight constriction at the isthmus, the sides punctulate except near poles and isthmus, cells in cross-section slightly oval, with ratio of diameters about 8 to 10, aspect from the narrower view cylindrical, with a very faint constriction at the isthmus L 28–32 μ, w 24 μ, w cell apex 14 μ, th 21 μ, isth 21 μ Pools Stas 146, Lookout Mt , F 8, Grandys Brook

This material shows longer cells than does typical *D quadratum*, and is more common than the typical form in these samples

DESMIDIUM SWARTZII Ag (Pl XXXIV, Fig 12) — L 21 μ, w 40–42 μ Pool Sta 140, Lookout Mt

The cells have a shallowly depressed apex like those of the British (Carter, 1923) form, rather than a plane one, as reported for Wisconsin (Smith, 1924) This is not readily observed, but is clear enough in empty filaments destitute of sheath

BAMBUSINA Kütz

BAMBUSINA BORRERI (Ralfs) Cleve (Pl XXXIV, Fig 16 [mamillate form], Pl XLIX, Fig 11) — L 26–30 μ, w median swelling 22–26 μ, w poles 14–17 μ Pools Stas 140, 145, 146 (major

[14] *Desmidium quadratum* var **doliiforme**, var nov — Cellulae cohaerentes filamenta longa formantes, compressae, cylindricae, a latere latiore visae dimidio longiores quam latae prope isthmum paulo constrictae, lateribus (isthmo polis exceptis) punctulatis, cellulis aspectu polari late ovatis axium ratione 8 10, cellulis a latere filamenti angustiore visis cylindricis, ad isthmum vix constrictis. Long 28–32 μ, lat 24 μ, lat pol 14 μ, crass. 21 μ, lat isth 21 μ Newfoundland, in loco dicto Lookout Mt , legit Bayard Long

item), Lookout Mt , 148, The Tableland, F 6, Great Barachois F 8, Grandys Brook

BAMBUSINA BORRERI var **attenuata**, var nov [15] (Pl XLIX, Fig 13) — Cells slender, in long cylindrical filaments, individual cells cylindrical, slightly inflated near the isthmus, which is feebly constricted, poles truncate-rounded, distal portion of each semicell faintly longitudinally striate L 55–65 μ, w median swelling 10 5 μ, w poles 7 0 μ Pool Sta F 8 (frequent), Grandys Brook

BAMBUSINA BORRERI var GRACILESCENS Nordst (Pl XLVIII, Fig 10) — Pools Stas 146, Lookout Mt , F 8, Grandys Brook

HYALOTHECA Ehrenb

HYALOTHECA DISSILIENS (Sm) De Bréb (Part I, Pl XLVII, Fig 16) — W c 20 μ Pools, ditches, and rivulets Stas 146, Lookout Mt , 148, The Tableland, F 8, Grandys Brook, B 20, 21, 26, 28, Whitbourne

HYALOTHECA DISSILIENS, var (Pl XLIX, Fig 15) — Ditches and pools Stas 102, McIvers Cove, 130, Lookout Mt

The variety was not sharply distinguishable in most of the material The cells were generally diffusely punctate toward the ends, and at times very markedly so, the isthmial region is quite smooth Grönblad (1921) recognizes punctae (pores) in this species

HYALOTHECA DISSILIENS var HIANS Wolle, f (Pl XLIX, Fig 16) — Cells of moderate size, forming long subcylindrical filaments, individual cells barrel-shaped, clearly but obtusely indented at the isthmial ring, moderately contracted toward the ends, at isthmus slightly oval, wall at the longest radii slightly denticulate, emphasizing the bilateral symmetry, membrane clearly porose from the crest near the isthmus, becoming somewhat more sparse toward the poles, chromatophore stellate, pyrenoid usually single L 17–19 5 μ, w 25–38 μ Pools and ditches Stas 102, McIvers Cove, B 20, St Johns, B 21, Whitbourne

[15] *Bambusina Borreri* var **attenuata**, var nov — Cellulae tenues, filamenta longa formantes, cylindricae prope isthmum debiliter constrictum paulo inflatae, polis ad centrum depressis margine rotundatis, semicellularum partibus apicalibus longitudinaliter striatis Long 55–65 μ, lat max. 10 5 μ, lat pol 7 0 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

The lesser indentation at the center and at the ends of the cells, with a somewhat greater width, distinguishes this form from the typical var *hians* Skuja (1930) figures a somewhat similar form of *H dissiliens* with cells much narrower than those of the variety at hand

Hyalotheca laevicincta, sp nov [16] (Pl XLIX, Fig 17) — Cells in long cylindrical filaments, individual cells subcylindrical, slightly swollen toward the ends but the central area with parallel sides, swollen ends relatively coarsely punctate, poles truncate, angles markedly rounded, chromatophore axial with radial plates, one or two pyrenoids to each cell L 18 30 μ, generally 20–25 μ, w central zone 12–17 μ, w end zones 13–19 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook (type)

HYALOTHECA MUCOSA (Dillw) Ehrenb (Part I, Pl XLVII, Fig 17) — L 21–26 μ, w 19 μ Pools Stas 146, Lookout Mt, B 21, Whitbourne

HYALOTHECA NEGLECTA Racib var **major**, var nov [17] (Pl XLIX, Fig 14) — Cells of moderate size, forming long cylindrical filaments, cells subcylindrical, slightly broader near the poles and isthmus, which is gently constricted, ends plane, angles barely rounded, membrane finely punctulate, chromatophore broad, flat, with two pyrenoids L 24–53 μ, w widest part, 13 2–17 μ, near pole, 11 3–16 μ Pools Stas 146, Lookout Mt (type), F 6, Great Barachois

The shape as figured by Carter (1923) is not in good agreement with that of the Newfoundland material, but the figures of Gronblad (1921) agree very well The cell size given by Carter for the species is much shorter than that of the Newfoundland material, although the extremes overlap, and the same thing is true

[16] **Hyalotheca laevicincta**, sp nov — Cellulae filamenta longa formantes, subcylindricae apicibus grosse punctatis subinflatae sed parte media lateribus stricte parallelis laevibus, polis truncatis, angulis rotundatis, chromatophoro axiali laminis radiatis praedito, somatibus pyrenoideis 1 vel 2 in cellula singula. Long 18–30 μ, saepe 20–25 μ, lat partic med 12–17 μ, lat max 13–19 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

[17] *Hyalotheca neglecta* var **major**, var nov – Cellulae mediocres quam eae formae typicae valde maiores, filamenta longa formantes, subcylindricae prope apices et isthmum vix constrictum paulo inflatae, polis planis, cum angulis marginalibus subrotundatis, membrana minute punctulata Long 24–53 μ, lat max 13 2–17 0 μ, lat pol 11 3–16 0 μ Newfoundland, in loco dicto Lookout Mt, legit Bayard Long

of Grönblad's material, in which the diameter is slightly less than that of the Newfoundland plants (l 33 37 μ, w 11 9 12 μ, w apex 10 6–11 5 μ)

HYALOTHECA NEGLECTA, f (?) (Part I, Pl XLVII, Fig 15) — Cells of small size, forming long cylindrical filaments, cells subcylindrical, barely larger toward the poles and isthmus, which is faintly constricted, ends plane or concave, angles slightly rounded, membrane faintly punctulate L 28–38 μ, w 17–18 5 μ Pool Sta 146, Lookout Mt

The chromatophores were single in the cell, indented at the isthmus, with two pyrenoids the centers of which are often doubled, the general form of the chromatophore appeared to be flat Wolle's figures (1892) on Plate 1, Figures 19 21, suggest this material, but he ascribes them to *Bambusina Borreri* (s syn *B Brebissonii*) as a juvenile stage, which is hardly plausible! It is probably a phase of the preceding variety

HETEROKONTAE

BOTRYOCOCCUS BRAUNII Kg — Pools Stas 116, St John Bay, 119, Ingornecholx Bay, 145 (major item), 146, Lookout Mt, 148, The Tableland, F 6, Great Barachois, F 8, Grandys Brook, F 9, Burgeo, B 26, Whitbourne

OPHIOCYTIUM ARBUSCULA Rabenh — Pool Sta B 26, Whitbourne

OPHIOCYTIUM CAPITATUM Wolle — Pool Sta B 26, Whitbourne

OPHIOCYTIUM COCHLEARE A Br — Wet thicket Sta 103, McIvers Cove

OPHIOCYTIUM MAJUS Naeg — Wet thicket and pool Stas 103, McIvers Cove, B 26, Whitbourne

OPHIOCYTIUM PARVULUM (Perty) A Br — Pool Sta B 26, Whitbourne

TRIBONEMA BOMBYCINUM Derb & Sol — Pools and wet ledges Stas F 4, 6, Great Barachois, F 8, Grandys Brook, F 9, Burgeo

TRIBONEMA BOMBYCINUM var TENUIS Hazen — Pools Stas F 9, Burgeo, B 14 (major item), St Johns

TRIBONEMA MINUS (Klebs) Hazen — Wet thicket Sta 103, McIvers Cove

TRIBONEMA spp — Stas 102, diam 7 μ, cells 5–8 μ long, McIvers Cove, 146, Lookout Mt, cells 13 μ diam, 10 25 μ long, walls thick, many chromatophores, suggesting *T obsoletum* West, 101,

Humbermouth, cells 8 5 μ diam, 10–13 μ long The general preservation of the material did not favor determinations in this genus, and since it was not floristically prominent, it was generally neglected

EUGLENOPHYCEAE

PHACUS PLEURONECTES (O F Müller) Dujard — Ditches and wet thicket Stas 102, 103, McIvers Cove

CHRYSOPHYCEAE

DINOBRYON SERTULARIA Ehrenb — Pool Sta B 26, Whitbourne

DINOBRYON SOCIALE Ehrenb — Pool Stas 145 (frequent), 146, Lookout Mt

DINOBRYON STIPITATUS Stein — Pool Sta 146, Lookout Mt

HYDRURUS FOETIDUS (Vilm) Kirchn — Streams Stas 128, 131, 132, Doctors Hill (major item)

DINOPHYCEAE

CERATIUM CURVIROSTRE Huitf -Kaas — Pools Stas 119, Ingornechoix Bay, 140, Lookout Mt, F 8, Grandys Brook

PERIDINIUM SP Pool — Sta 140 (frequent), Lookout Mt

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INDEX OF GENERA

(This index includes the genera listed in Part I in the preceding volume)

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EXPLANATION OF PLATES XXXIII-XLIX

In general throughout these plates nuclei have been stippled solid, chromatophore and pyrenoid outlines have been indicated by dotted lines, but since these are made from preserved material they are not to be considered critically illustrative of the living cell; broad lenticular membrane thickenings have been indicated by concentric dotted lines, punctulation and granulation have been indicated by dots or by circles of appropriate size on part of the cell surface, but if very delicate have been omitted Drawings of the same species if adjacent have been connected by a dotted line, and if separated on the plate generally have been indicated by a letter attached to the figure number All figures are original, executed by the author from the Newfoundland material, and reduced by about three fifths in reproduction

PLATE XXXIII

Staurastrum

1 *S dejectum* var *patens*, side and top views, × 725

2 *S cuspidatum*, side and top views of two cells, × 565

3 *S cuspidatum* var *canadense*, f , × 565

4 *S mucronatum subtriangulare*, side and top views, × 565

5. *S cuspidatum* var *canadense*, × 725

6 *S apiculatum*, × 725

7 *S aversum*, × 725

8 *S mucronatum*, f , × 725

9 *S orbiculare* var *extensum*, f , side and top views, × 725

10 *S pyramidatum*, side and top views, × 725

11, 13 *S botrophilum*, side and top views of two cells, × 565

12 *S Dickiei*, × 725

14 *S. brevispinum*, f , × 675

15. *S brasiliense* var *Lundellii*, side and top views, × 340

(See also Plate LVII in Part I and Plates XXXIV-XXXVIII.)

PLATE XXXIII

PLATE XXXIV

Staurastrum

1 S *pachyrhynchum* face and top views × 725

2 S *furcatum* × 725

3 S *Arcula* var *subarcuata*, face and top views, × 725

4 S *polymorphum* f face and top views × 850

5 S *Ravenelii* face and top views, × 725

6 S *sibiricum* var *occidentale*, × 725

7-7a S *anatinum* var *curtum*, side and top views, × 725

8 S *cosmarioides* × 565

9 S *grande* var *parvum* side and top views × 565

10 S *setigerum* top view × 725

(See also Plate LVII in Part I and Plates XXXIII XXXV–XXXIX)

11 *D Grevillii* portion of filament, × 565

12 *D Swartzii*, portion of filament × 565

13 *D aequale* portion of filament, × 565

14 *D quadratum* var *doliiforme*, var nov portion of filament from face and edge views × 725

15 *D gracilicps* f *major*, portions of filament from face and edge views × 565

(See also Plate XLIX)

Bambusina

16 *B Borreri* portion of filament of type showing mammillate sinus × 725

(Plate XLIX)

PLATE XXXIV

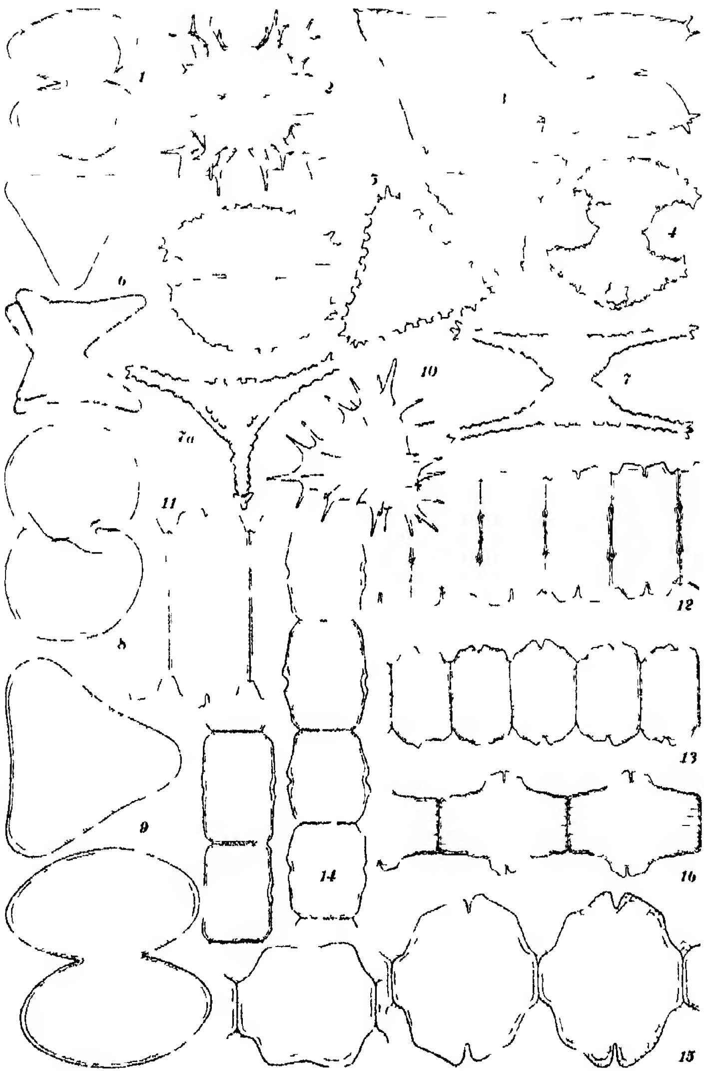


PLATE XXXV

Staurastrum

1 *S. subscabrum* f. *scabrior*, side and top views, × 725

2 *S. quadrispinatum*, × 725

3 *S. teliferum*, side and top views, × 725

4 *S. muricatum*, side and top views, × 725

5 *S. striolatum*, two side views, × 725

6 *S. alternans*, side and top views, × 725

7 *S. punctulatum* var. *pygmaeum*, side and top views, × 725

8 *S. punctulatum*, side and top views, × 725

9 *S. dilatatum*, side and top views, × 725

10, 11 *S. geminatum* var. *longispinum*, two cells, side and top views, × 725

12 *S. tetracerum*, × 725

13 *S. tetracerum* f. *trigonum*, × 725

14 *S. iotanum*, × 725

15 *S. Meriani*, × 725

16 *S. inflexum*, × 725

17, 18 *S. paradoxum*, × 725

19 *S. paradoxum*, f. (?), × 565

20 *S. subnudibrachiatum* f., × 725

21 *S. brachiatum*, × 725

(See also Plate LVII of Part I and Plates XXXIII–XXXIV, XXXVI–XXXIX.)

PLATE XXXV

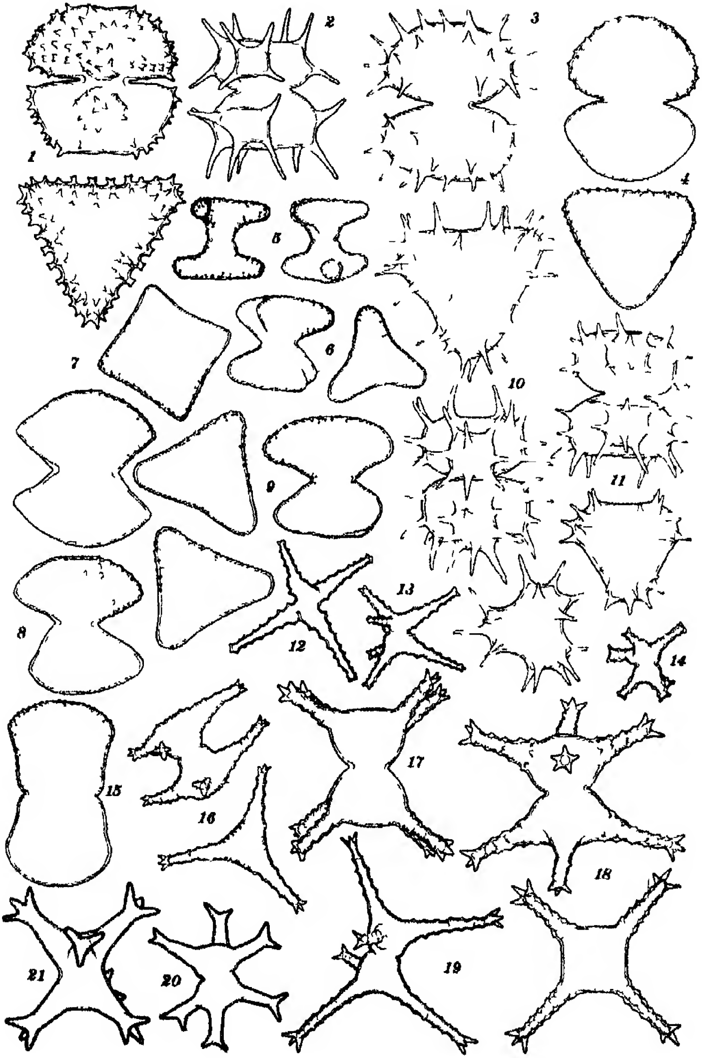


PLATE XXXVI

Staurastrum

1, 2. S. *elongatum*, side views of cell and semicell, × 565, × 725

3. S. *pelagicum* var. *longibrachiatum*, var. nov., side and top views, × 565

4. S. *novae terrae*, sp. nov., side and top views, × 725

5. S. *Fernaldii*, sp. nov., side and top views, × 725

6. S. *subcruciatum*, × 725

7. S. *furcigerum* f., × 725

8. S. *furcigerum*, side and oblique top views, × 415, × 565

9, 10. S. *Clevei*, top and two side views, × 565

11. S. *furcatum* var., × 725

12, 12a. S. *vestitum*, oblique and top views, × 725, × 565

13. S. *Arctiscon*, × 340

14, 14a. S. *Arctiscon* f., side view and tip of arm, × 340, × 850

15. S. *Cerastes*, × 725

(See also Plate LVII of Part I and Plates XXXIII, XXXV, XXXVII–XXXIX.)

PLATE XXXVI

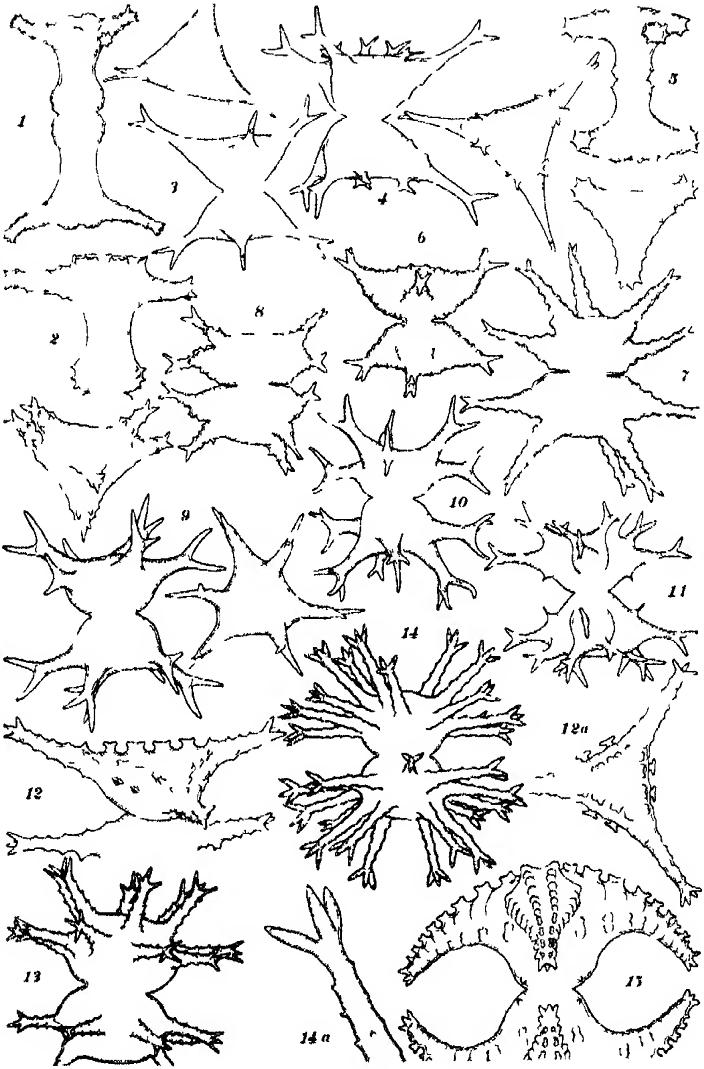


PLATE XXXVII

Staurastrum

1. S. *margaritaceum* f., side and top views, × 725
2. S. *protectum* var. *planctonicum*, side and top views, × 630

3–3a. S. *Heimerlianum* f. (?), side and top views, × 725

4. S. *polymorphum*, side and top views, × 725
5. S. *crenulatum* f., side and top views, × 850
6. S. *furcatum* var. *aculeatum* (?), top view, × 725
7. S. *setigerum*, × 725
8. S. *Rotula*, top view, × 340
9. S. *Arctiscon*, top view, × 340
10. S. *ankyroides* var. *pentacladum*, top and side views, × 450

11, 13. S. *Ophiura*, top and side views, × 450

12. S. *pentacerum*, top view, × 340
14. S. *furcatum*, f., side and top views, × 725

(See also Plate LVII of Part I and Plates XXXIII, XXXVI, XXXVIII, XXXIX.)

PLATE XXXVII

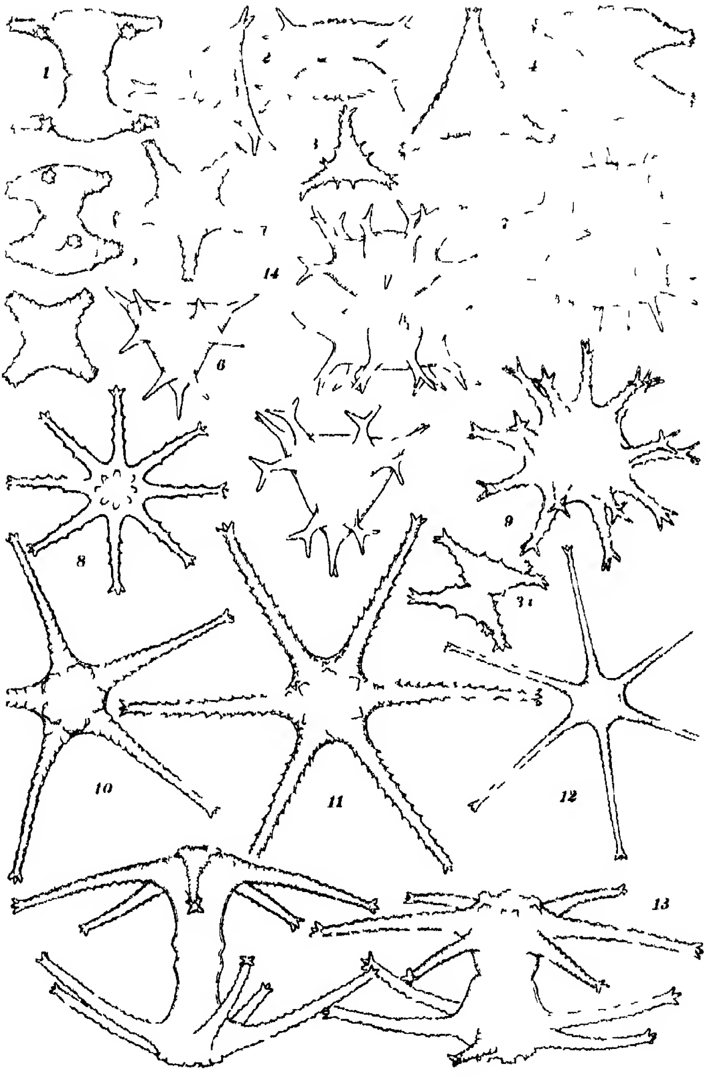


PLATE XXXVIII

Staurastrum

1–2. *S. natator*, side view of two cells, top and edge views, × 565

3–4. *S. bioculatum* sp. nov., side view of two cells, top and edge views, × 565

5–6. *S. Johnsonii*, side view of two cells and top view, × 565

7–8. *S. bicorne*, side view of two cells, top and basal views of semicell, × 470

9. *S. Anchora*, × 470

10. *S. americanum* var. *longiradiatum*, × 725

(See also Plate LVII of Part I and Plates XXXIII, XXXVII, XXXIX.)

PLATE XXXVIII

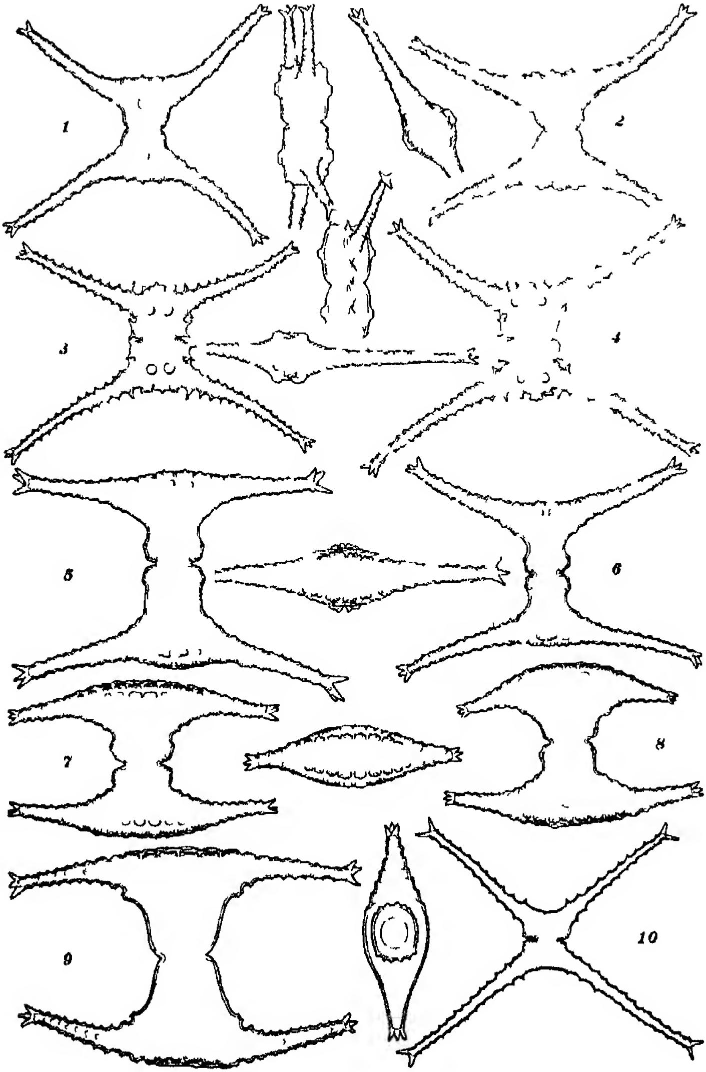


PLATE XXXIX

Euastrum

1 *E abruptum* f *minus* × 850

2 *E montanum*, × 850

3 *E binale* f *hians* × 850

4 *E Boldtii* var *isthmochondrum* f × 850

5 *E insulare*, × 725

6 *E pulchellum* var *retusum* f (?) × 725

7 *E doliiforme* var × 725

8 *E Turneri*, f × 725

9 *E pingue* × 565

10 *E bidentatum* × 565

(See also Plates XI–XI III)

Tetmemorus

11 *T laevis*, × 470

(See also Plate XLIII)

Staurastrum

12 *S boreale* side top and oblique views × 470

13 *S gracile*, top view × 470

14 *S subcruciatum* × 725

15 *S polytrichum* top view, × 725

16 *S Sebaldii* var *ornatum*, top view × 455

17 *S anatinum* var *truncatum*, side and top views, × 565

18 *S grallatorium*, var , side and top views × 565

19 *S leptocladum*, side and top views, × 455

(See also Plate LVII of Part I and Plates XXXIII–XXXVIII)

PLATE XXXIX

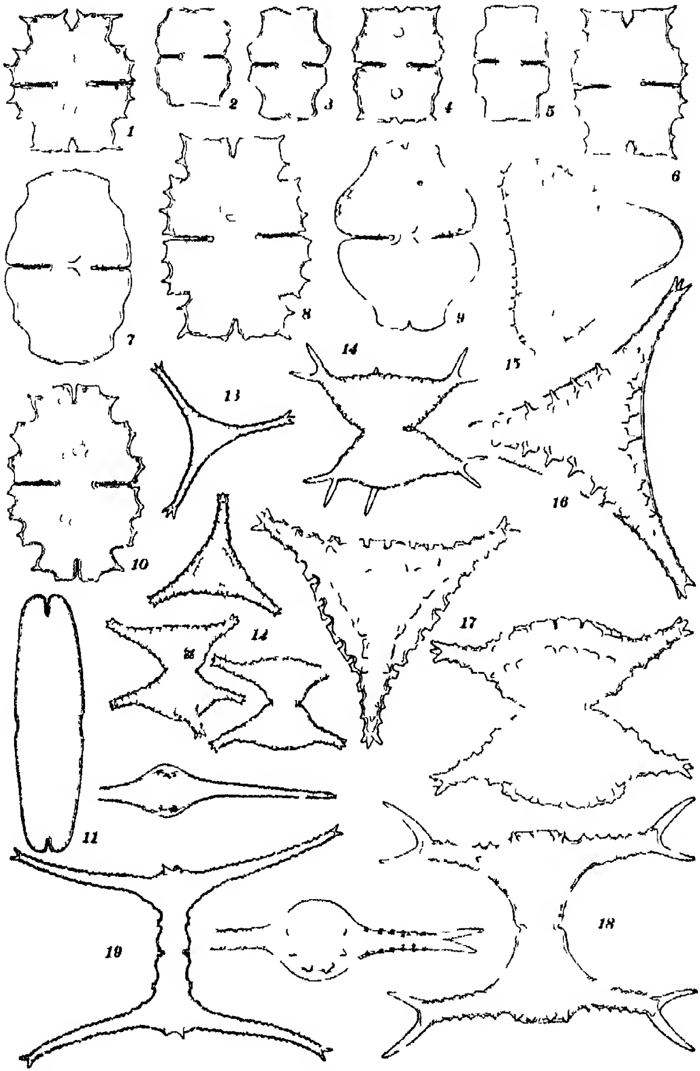


PLATE XI

Euastrum

1–3. *E. binale*, three cells × 725

4. *E. binale* var. *Gutwinskii*, face view × 725

5–6. *E. insulare*, two cells × 725

7. *E. validum* × 725

8. *E. Cornubiense*, face and top views × 725

9. *E. sinuosum* var. *reductum* f. (?), × 565

10. *E. inerme* × 565

11. *E. subhexalobum* × 725

12. *E. pictum* var. *subrectangulare* f. × 565

13. *E. bidentatum* × 725

14. *E. pectinatum* var. *reductum* var. nov., face, edge, and top views × 565

15. *E. pectinatum* var. *inevolutum*, face and edge views × 565

16. *E. pectinatum* var. *brachylobum* f. *majus*, f. nov., face and edge views × 565

17. *E. lapponicum*, × 815

18. *E. binale*, face and top views, × 850

19. *E. ansatum* × 565

20. *E. crassum* var. *scrobiculatum* × 445

21. *E. cuneatum*, × 450

(See also Plates XXXIX, XLI, XLIII.)

PLATE XL

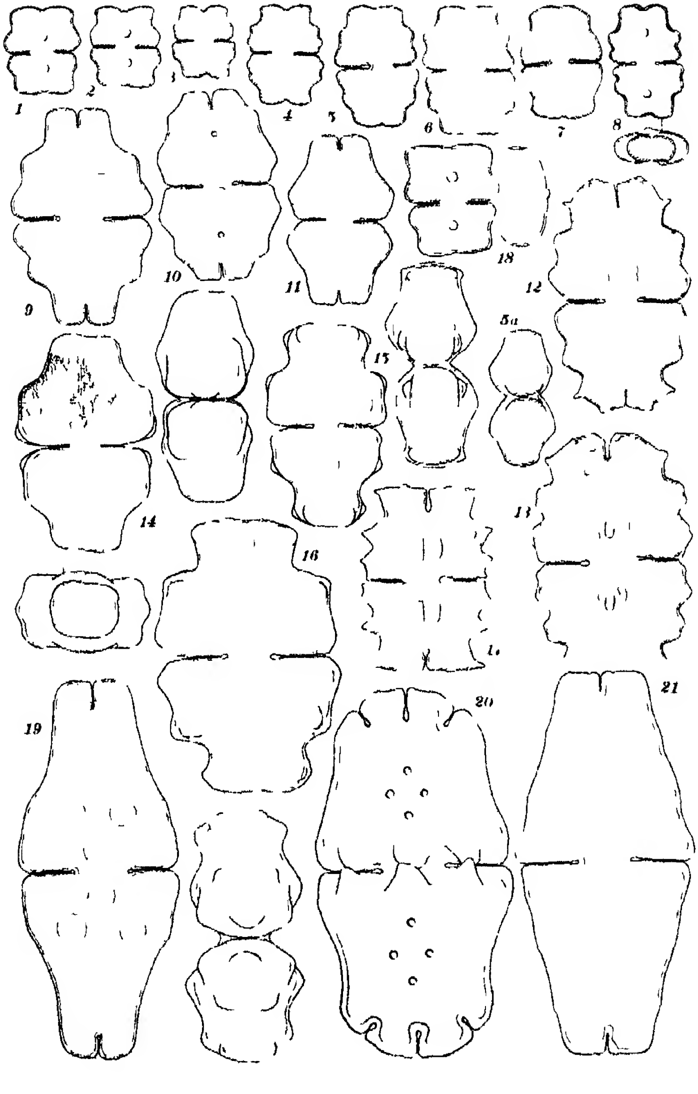


PLATE XLI

Euastrum

1 *E. bidentatum* × 565

2 *E. pinnatum,* × 455

3, 3a *E. tuddalense* var. *novae terrae* var. nov., face and top views × 850

4 *E. pectinatum* var. *brachylobum* f. *rostratum,* f. nov. face and top views, × 565

5 *E. Allenii* face, edge, and top views × 565

6 *E. pinnatum* f. face, edge, and top views × 470

7 *E. oblongum* face and edge views, × 385

8–8a *E. giganteum* var. *latum* var. nov., face and edge views, × 340

9 *E. humerosum* face and edge views, × 485

(See also Plates XXXIX–XL, XLII–XLIII.)

PLATE XLI

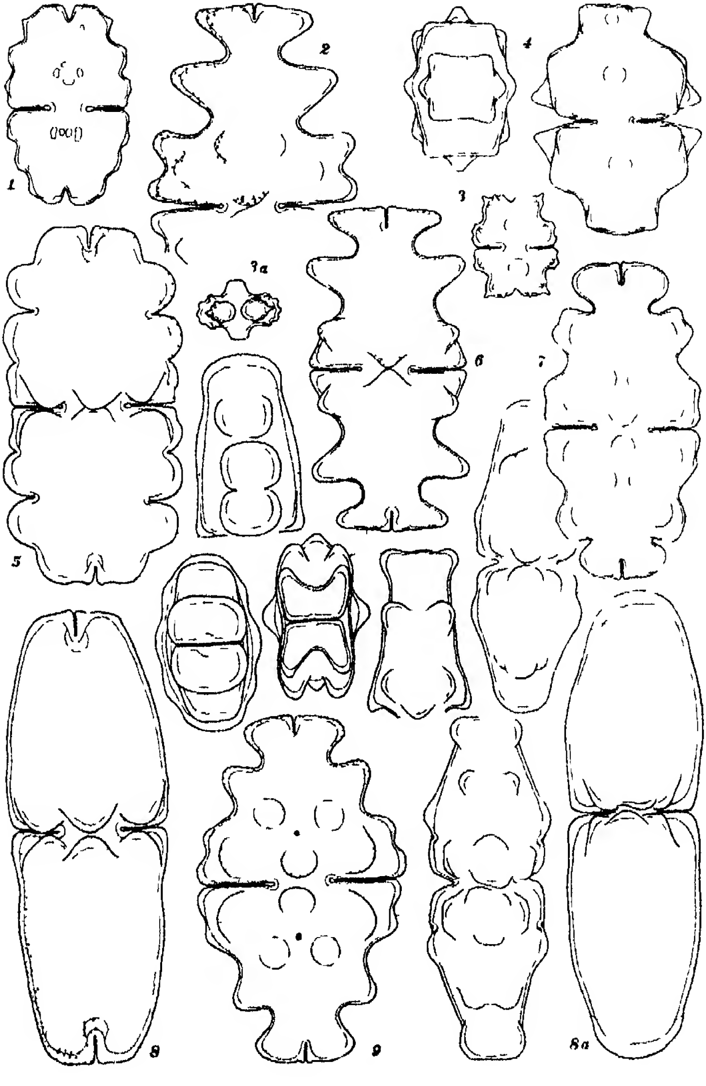


PLATE XLII

Euastrum

1. *E. didelta*, face and edge views, × 565

2–3. *E. ampullaceum*, cell face and tip of another individual, × 565

4. *E. intermedium* var. *validum*, × 565

5. *E. insigne*, face and edge of cell, × 565

6. *E. didelta*, face, edge, and top views, × 385

7. *E. Wollei* var., × 340

8. *E. oblongum* f., × 470

9. *E. ventricosum*, × 565

10. *E. oblongum*, × 185

(See also Plates XXXIX, XLI, XLIII.)

PLATE XLII

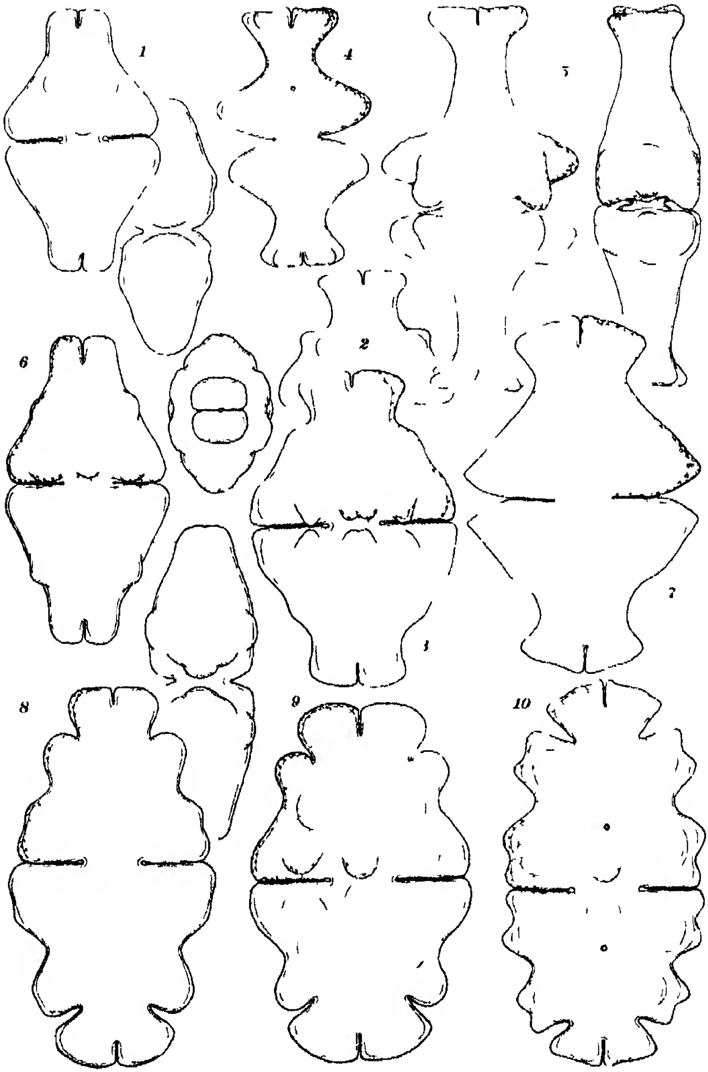


PLATE XLIII

Euastrum

1. *E. cuspidatum*, × 725
2. *E. pulchellum* var. *retusum* f. (?), × 725
3. *E. Boldtii* var. *isthmochondrum*, f., × 850
4. *E. elegans*, × 850

5-6. *E. elegans* var. *ornatum*, two cells, edge and face views, × 850

7. *E. gemmatum*, face, edge and top views, × 725
8. *E. insigne* f., empty semicell face, × 565
9. *E. cuspidatum*, × 725
10. *E. ventricosum*, × 725
11. *E. crassum* var. *scrobiculatum*, × 385
12. *E. verrucosum*, × 450

(See also Plates XXXIX–XLII.)

Tetmemorus

13. *T. granulatus* var. *attenuatus*, × 565
14. *T. laevis*, × 525
15. *T. Brebissonii* var. *minor*, × 585

16-17. *T. Brebissonii*, two cells, × 300, × 340

18. *T. granulatus*, × 340

(See also Plate XXXIX.)

PLATE XLIII

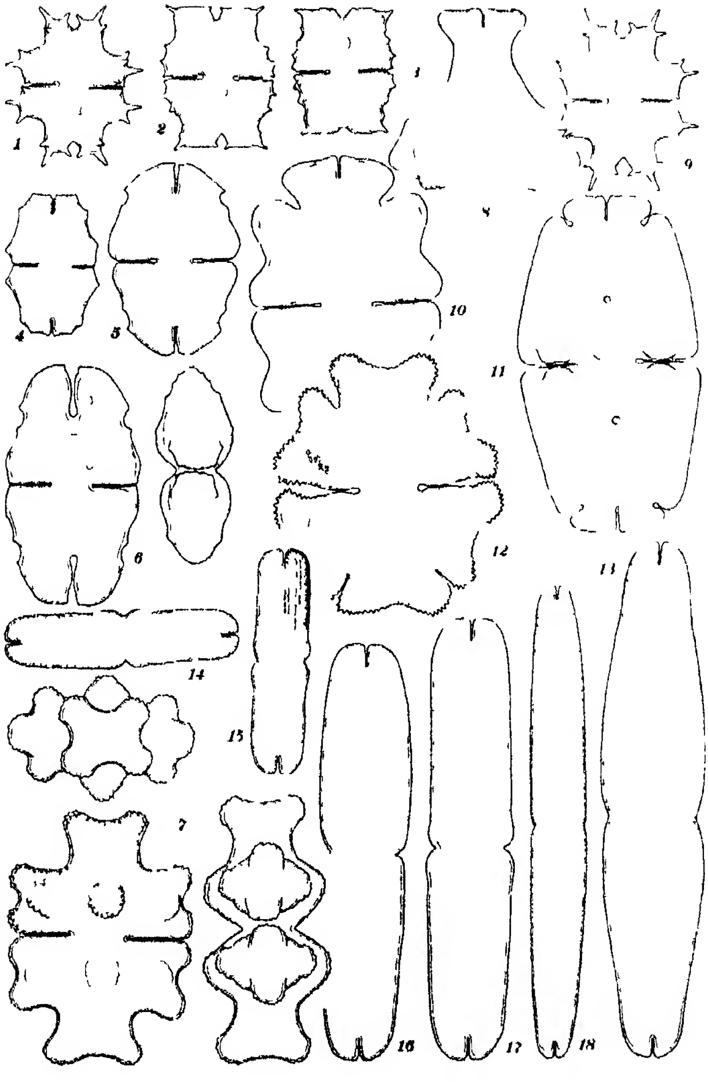


PLATE XLIV

Micrasterias

1 *M radiata* var *gracillima* × 340

2 *M Jenneri* var *simplex* × 385

3 *M foliacea* × 565

4 *M expansa* × 565

5 *M pinnatifida* × 565

6 *M arcuata* × 565

7 *M oscitans* × 340

(See also Plates XLV–XLVIII)

PLATE XLIV

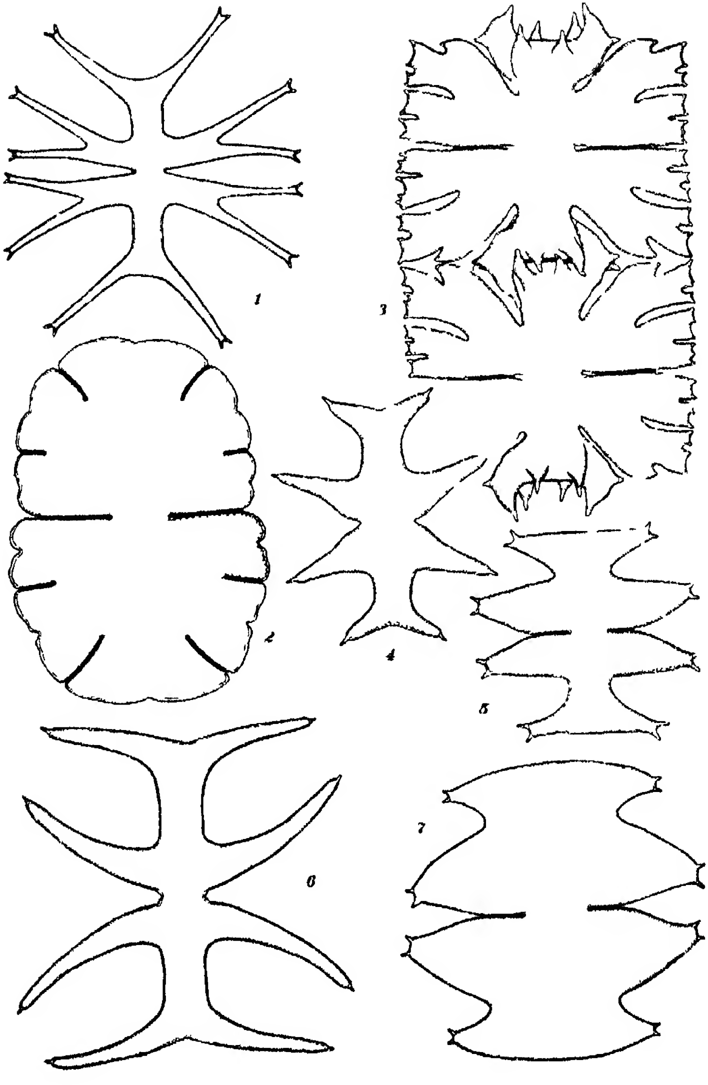


PLATE XLV

Micrasterias

1 *M radiata* × 340

2 *M radiosa* var *ornata* f *elegantior*, × 340

3 *M conferta* var *novae terrae* × 505

4 *M Jenneri* var *simplex*, × 315

5 *M americana* × 455

6 *M apiculata* var *brachyptera* × 385

7 *M Thomasiana* var × 285

8 *M triangularis*, × 315

(See also Plates XLIV, XLVI–XLVIII)

PLATE XLV

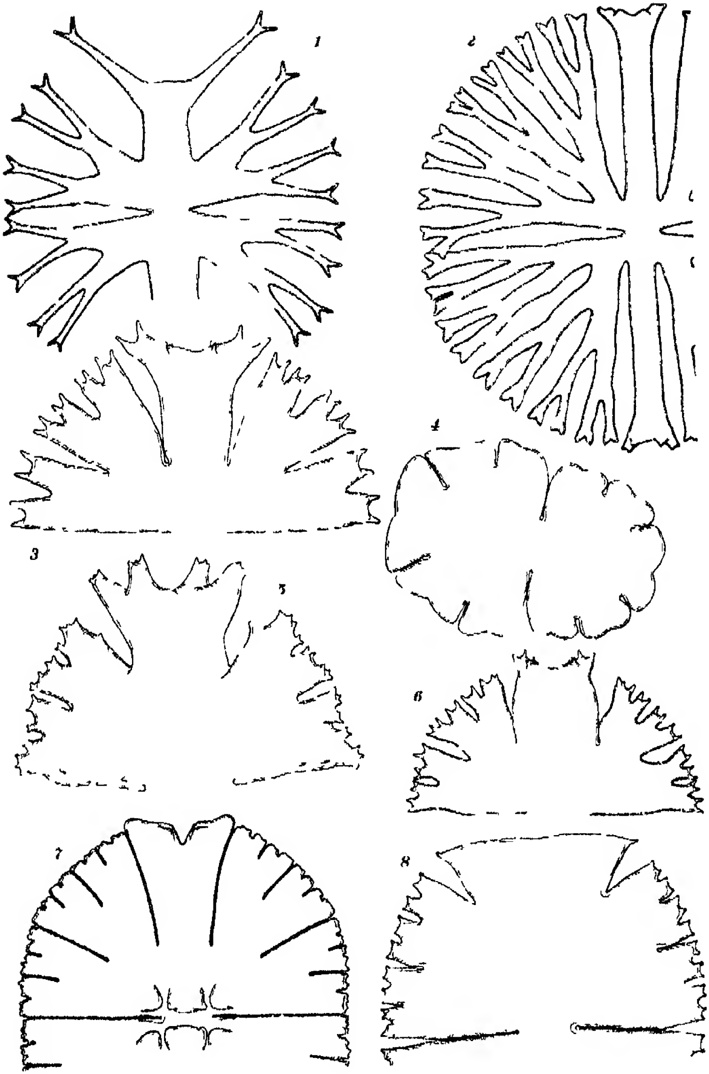


PLATE XLVI

Micrasterias

1 *M papillifera* var *glabra* f × 565

2 *M papillifera* f, × 340

3 *M conferta* × 455

4 *M papillifera*, × 565

5 *M truncata*, × 470

6 8 *M truncata* var *turgida* var nov , face edge and top views × 565

(See also Plates XLIV XLV XLVII XLVIII)

PLATE XLVI

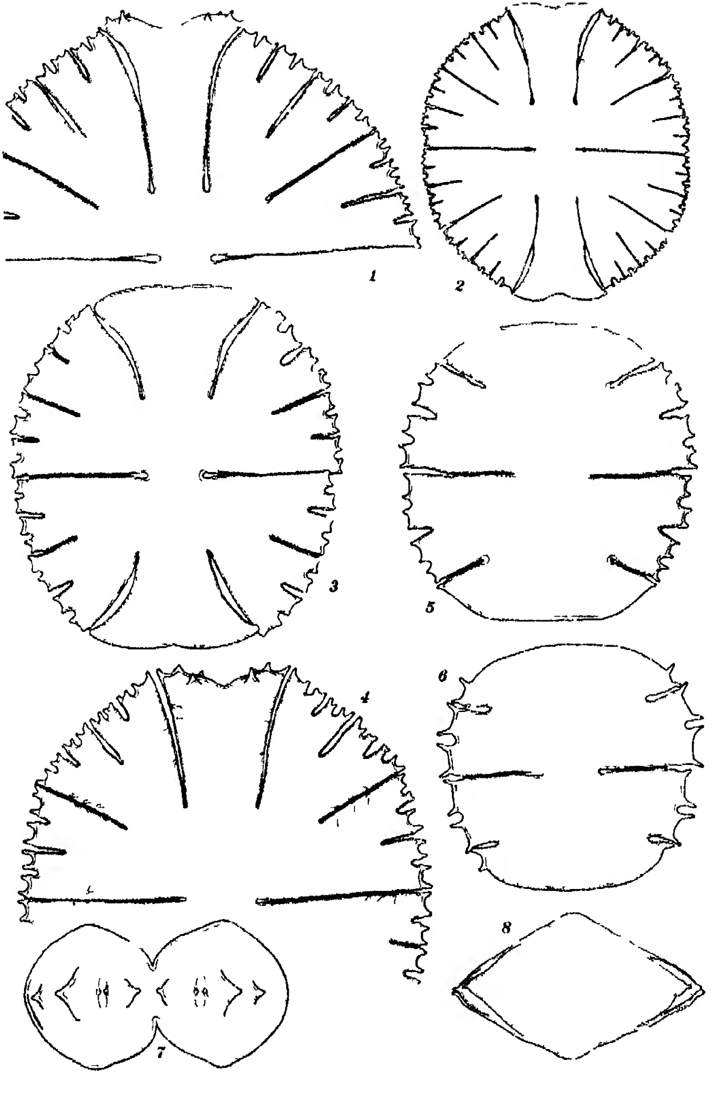


PLATE XLVII

Micrasterias

1 *M expansa* × 565 Four cells, showing (left) the maximum approach toward *M arcuata* observed in this material, and (right) the maximum condensation of the arms

2 *M truncata* var *turgida*, var nov, × 480 Cell showing arrested separation of the semicells after division had progressed to segregation of four chromatophores in the juvenile portion, as outlined by dotted lines

3 *M truncata* var *turgida*, var nov, × 565 Eleven semicells showing wide variation and teratology including stout facial lobes, all specimens represented had walls of adult texture

Cosmarium

4 *C tetraophthalmum* var *pyramidatum* × 300, cell showing arrested separation of semicells (described in Part I pp 269–270)

(See also Plates XLIV–XLVI, XLVIII)

PLATE XLVII

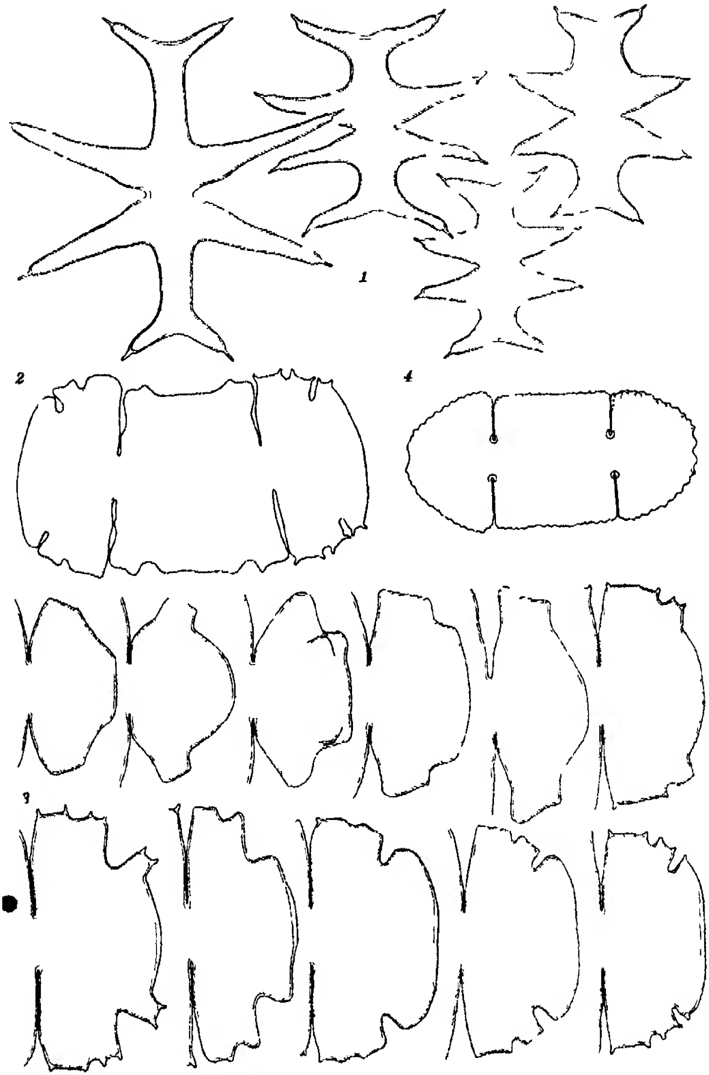


PLATE XLVIII

Micrasterias

1. *M. conferta* var. *novae terrae*, × 565
2. *M. speciosa*, × 565
3. *M. radiosa* var. *ornata* f. *elegantior*, × 340
4. *M. radiosa* var. *ornata*, × 340
5. *M. Johnsonii* var. *bipapillata* var. nov., × 225
6. *M. radiosa* f., × 56
7. *M. apiculata* var. *fimbriata*, × 225
8. *M. oscitans*, top view, × 225

(See also Plates XLIV–XLVII.)

PLATE XLVIII

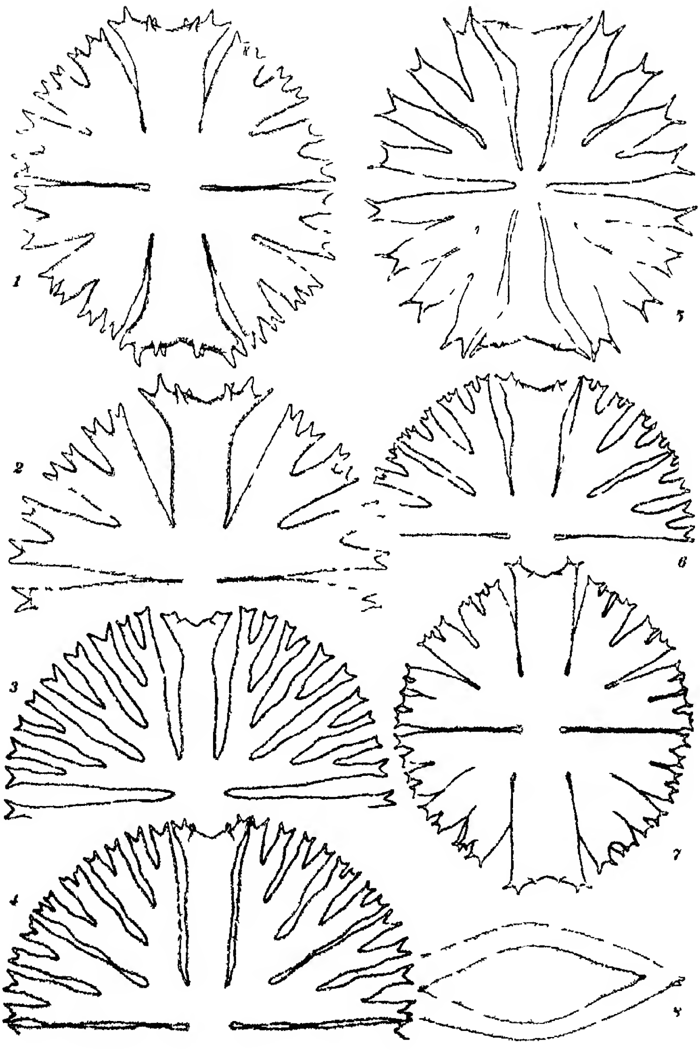


PLATE XLIX

Desmidium

1 *D. Baileyi* × 565

2 *D. Aptogonum* var. *acutius* × 565

3 *D. Aptogonum* var. *ovale* var. nov., side of filament and top view of cell, × 470

4, 5 *D. Grevillii* side views of two portions of filament showing aspect in position of lesser and greater dimensions × 565

6 *D. quadratum* × 565

(See also Plate XXXIV.)

Spondylosium

7 *S. planum*, × 565

8 *S. pulchrum* portion of filament and edge and top views of cell × 340

Sphaerozosma

9 *S. Aubertiana*, × 565

Bambusina

10 *B. Borreri* var. *gracilescens* × 725

11–12 *B. Borreri*, portion of filament in surface and portion in optical section showing replicate wall as formed after cell division, × 725 × 650

13 *B. Borreri* var. *attenuata*, var. nov. × 725

(See also Plate XXXIV.)

Hyalotheca

14 *H. neglecta* var. *major* × 725

15 *H. dissiliens*, var., × 565

16 *H. dissiliens* var. *hians* f. portion of filament and end of cell × 565

17 *H. laevicincta*, sp. nov., × 725

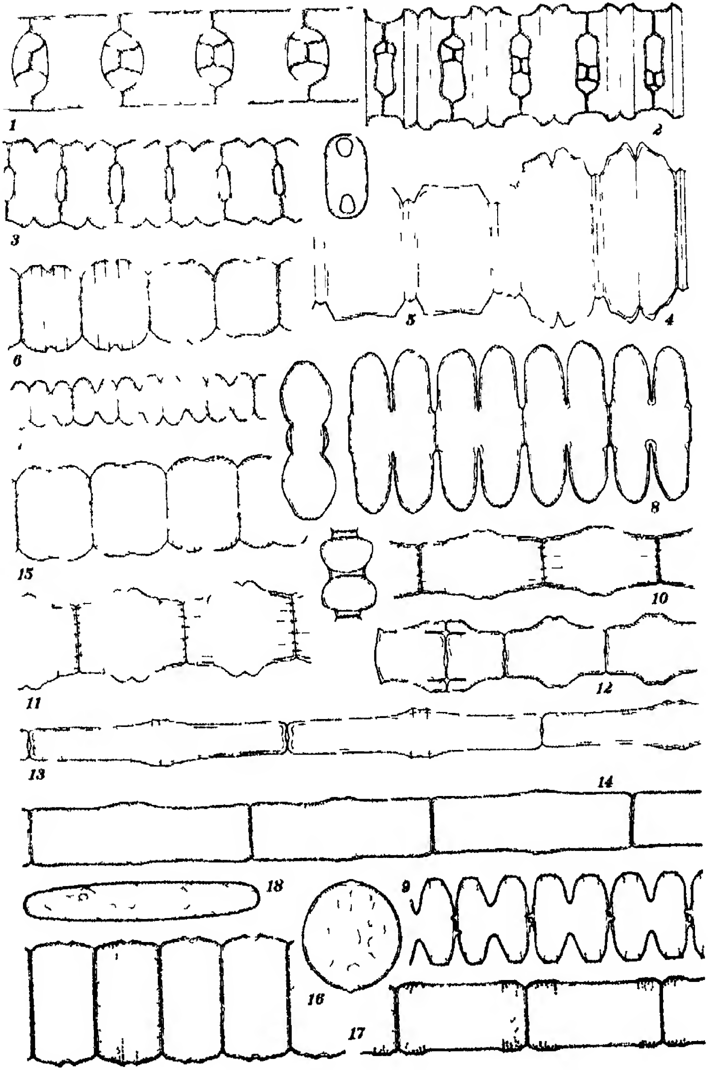
(See also Plate XLVII of Part I.)

Spirotaenia

18 *S. sp.* (?), × 525

(See also Plate XLV of Part I.)

PLATE XLIX



MAESA HIRSUTA (MYRSINACEAE), A NEW SHRUB FROM KWEICHOW, CHINA *

EGBERT H WALKER

CRITICAL studies of the collections made by various recent expeditions into little-explored Kweichow Province are revealing a rather large number of new plant forms Since Dr Heinrich Handel-Mazzetti, the noted Austrian specialist on Chinese botany, traversed the province on his expedition during the years 1914–18, he has received for study a large part of these specimens Among those collected in this province in 1930 by Y Tsiang (Tsiang Ying) under the auspices of the Metropolitan Museum of Natural History in Nanking, China, was a specimen which apparently represented a new species of Maesa Since the writer is engaged in a critical revision of the eastern Asiatic members of the Myrsinaceae, this specimen was kindly lent him for study at the United States National Museum, and the supposition of its distinctness was confirmed Subsequently Dr Handel-Mazzetti offered the writer the privilege of naming and publishing this new species

The Asiatic species of the genus Maesa, along with most of those of the other genera of Myrsinaceae represented in this area, are in a state of great confusion owing to the intergrading of specific characters It is increasingly evident that there is a close relationship between the Chinese species of Maesa, especially those from the western provinces, and those of India, Burma, and Siam, a fact which has apparently been overlooked by recent students of the Chinese species Hence, any treatment of the northern forms must be regarded as provisional until a larger representation of the more tropical forms can be assembled and critically studied This the writer has as yet been unable to do in a sufficiently satisfactory degree.

The Chinese Maesa under consideration belongs in the group with corolla tube nearly equal to the lobes, as contrasted with those

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having the tube about three times as long as the free portion The densely hirsute branches, together with the rough, hirsute upper surfaces of the leaves, distinguish it from the related pubescent species in that group The only available information concerning the habit of the plant is the statement on the field label that it is a small shrub Since the vegetative characters must be relied on largely to separate the species in this genus, this one is here considered distinct

Maesa hirsuta Walker, sp nov

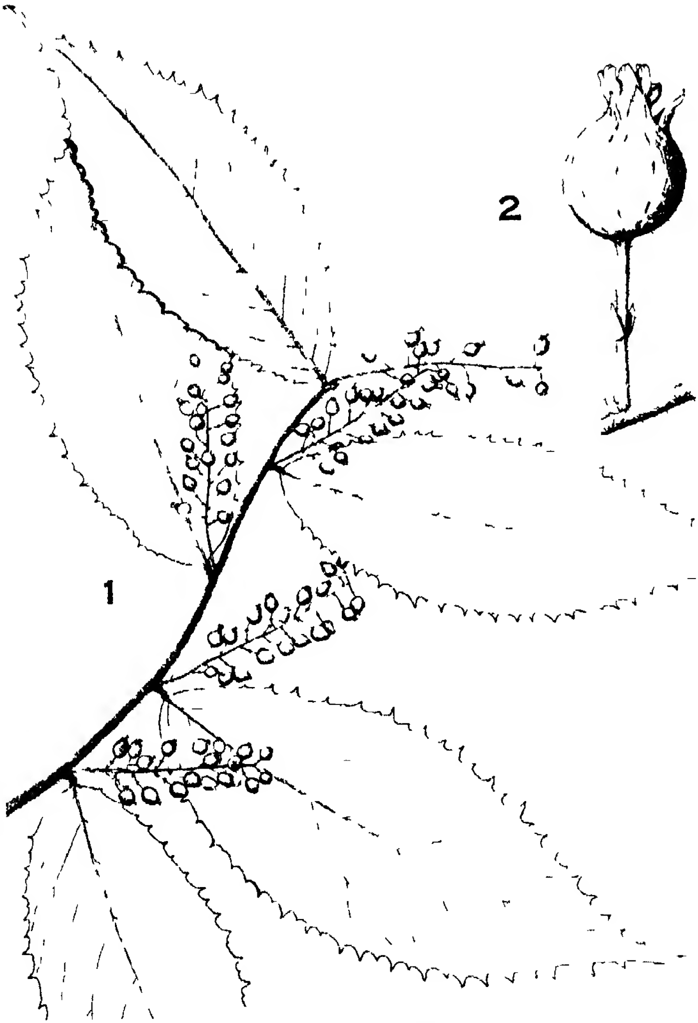
(Plate L)

Arbuscula parva fere undique hirsuta praesertim ramulis tenuibus, folia breviter petiolata, petiolus vix 5 mm longus, dense hirsutus, lamina tenui chartacea, 15–19 cm longa, 6–7 cm lata, elliptico-ovata, basi rotundata vel late obtusa, apice acuta extremitate tenuiter acuminata, grosse serrata, dentibus acutis triangularibus, supra opace viridi, infra paulo pallidiore, utroque scabrido-hirsuta praesertim subtus et in costa tenui elevata, nervibus lateralibus circa 10-jugis, ramosis, in dentibus desinentibus, inflorescentia racemosa, axillaris, circa 6 cm longa, hirsuta, pedicellis 5 mm longis tenuibus, bracteolis angustis lanceolatis prope medium fructus locatis, sepala triangulari-ovata, acuta, fere 2 mm longa, hirsuta, neque punctata neque prominule glanduloso-striata, corollae tubus lobis vix longior, lobis 3 mm longis suborbicularibus glanduloso-striatis, glabris, stamina in floribus femineis reducta, in floribus masculis quam corolla breviora, filamentis brevibus, antheris ovatis vix 1 mm longis, pistillum sepalis subaequale, stigmate 4-lobato vel 4-diviso, stylis vix 1 mm longis, ovario globoso subinferiore, fructus circa 5 mm longus, ovoideus, apiculatus, albus, siccitate flavescens, hirsutus, obscure glanduloso-striatus.

Type in the herbarium of H Handel-Mazzetti, Vienna, Austria, collected by Y Tsiang et Si-mi-yao, Pa-na, Cheng-feng Hsien, Kweichow Province, China, October 24, 1930, No 4405 A fragment and a photograph are deposited in the United States National Herbarium, No 1,577,836 An additional specimen in the New York Botanical Garden was collected by A N Steward and C. C. Cheo at Chi Tung, Lin Yuin Hsien, Kwangsi Province, May 5, 1933, No. 315

National Herbarium, Smithsonian Institution
Washington, D C

PLATE I



Maesa hirsuta Walker

1 Branchlet × ½ 2 Fruit with old corolla × 4

CONTRIBUTIONS TO A STUDY OF THE FUNGOUS FLORA OF NOVA SCOTIA I *

LEWIS E WEHMEYER

THE Province of Nova Scotia presents a particularly fertile field for the mycologist Situated as it is in 44°–47° north latitude, nearly surrounded by water and bathed on the southern coast by the warm Gulf Stream, it has a moist temperate climate very favorable to the development of many species of fungi, especially the fleshy types

The Province consists of a peninsula which lies in an easterly and westerly direction and is traversed by two high dividing ridges and numerous parallel lower ridges and hills The southern watershed divides it longitudinally into two halves The southern half is almost entirely a granitic or quartzitic region, with numerous parallel streams cutting across the larger ridges and emptying into the Atlantic Ocean The region also contains numerous lakes and bogs North of this watershed the underlying strata are chiefly sedimentary sandstones and slates, with a backbone of igneous and metamorphic rocks forming an interrupted line of hills running the length of the north or north-central part of the Province The drainage in this area is northward into the Bay of Fundy, Minas Basin, Cobequid Bay, and Northumberland Strait It was here that most of the writer's collections were made (For a further discussion of the typography and the geology of the Province and their relation to forest types the reader is referred to C D Howe's part of Fernow's report [7, p 43])

Much of the charm and interest of collecting in this Province lies in the variety of ecological situations and in the abundance of the fungi, both species and individual plants, found therein About 52 5 per cent of the Province is forested Of this area 73 per cent is a mixed forest of conifers and hardwoods, 20 per cent is of pure conifers, and 7 per cent pure hardwoods (7) *Abies balsamea* and

* Papers from the Department of Botany and the Herbarium of the University of Michigan, No 434.

Picea rubra, which are the most abundant coniferous species, often form pure stands, either singly or together. Other conifers, such as *Tsuga canadensis*, *Picea canadensis*, *P. mariana* (in cold swamps), *Larix laricina*, and *Pinus Strobus*, occur mostly as scattered trees or as local stands. The dominant hardwoods are of the beech, birch, and maple type, including *Fagus grandifolia*, *Betula papyrifera*, *B. populifolia*, *B. lutea*, *Acer saccharum*, *A. spicatum*, and a scattering of *A. pennsylvanicum*. Along the stream beds are *Alnus incana*, *Populus tremuloides*, *P. grandidentata*, and various species of Salix. Besides these there are scattered individuals of *Ulmus americana*, *Prunus serotina*, *P. virginiana*, *Pyrus americana*, *Cornus alternifolia*, Ostrya, Carpinus, Fraxinus, Crataegus, Amelanchier, and other associated species. The shrubby and herbaceous flora is similar to that of northern New England. Ferns and mosses are particularly abundant in both the forested and the open areas. These forested areas, with their rich humus and abundant dead and decaying woody matter, are particularly productive of saprophytic and fleshy fungi. The many marsh and swamp areas, besides presenting a different variety of fleshy and saprophytic forms, also provide distinctive host plants which harbor numerous parasitic fungi. Typical acid bogs in the lower flats either have an open shrubby growth composed chiefly of *Rhododendron canadense*, *Ledum groenlandicum*, various Vaccinia, and other shrubs or are forested with Larix, *Picea mariana*, Salix, etc. Swamps are also found on the slopes and ridges in the heavily forested regions, where there occur all transitions from bogs to mere wet depressions filled with mosses, ferns, or low shrubs. The extensive grassy and cut-over lands also have characteristic host plants as well as saprophytic fungi, such as field mushrooms and Lycoperdaceae. About the shores of Minas Basin and Cobequid Bay there are large brackish marshes which are periodically inundated by the tides of the Bay of Fundy and which furnish distinctive sedges, grasses, and other herbs that serve as hosts to many parasitic fungi. The extensive coast line with many sandy beaches also provides a characteristic flora, which harbors many interesting fungi.

There still remains a large field for work on the fungi of the Province. Several lists of fungi collected in Nova Scotia have been published by Somers (22–27) and MacKay (14–15). These earlier reports are chiefly of the fleshy fungi, particularly the Agaricaceae and Polyporaceae. There are also a few published accounts of

special groups, such as the rusts by Fraser (9), Myxomycetes and aquatic fungi by Moore (16–17), Erysiphaceae by Mussels and Parker (18) and by Fraser (10), and of forest diseases by Faull (6), but beyond the scope of these papers there lies a virgin field which should yield much of mycological interest

The writer's studies on Nova Scotian fungi are based largely on material gathered over a period of some five years In June of 1926 several weeks were spent about Truro and in the region of Wolfville, in September of 1927 a few collections were made on Cape Breton Island During the summer of 1929 the months of July and August and part of September were spent in collecting, chiefly in Colchester County In 1931 the writer was accompanied by A H Smith, and a permanent headquarters at Upper Brookside, near the town of Truro, was established During this summer trips to various parts of the Province were made, and special attention was paid to the fleshy fungi A R Prince, of the Provincial Agricultural College at Truro, has kindly donated a number of collections made by himself and others In all, well over fifteen hundred collections have been obtained for study The area covered is more or less limited to the northern and eastern parts of the Province It has, also, been impossible to make collections of the early spring or later fall flora, but, in general, a fairly representative collection has been obtained

Nova Scotia is of particular interest from a distributional point of view For the most part the fungous flora is similar to that found in northern New England or in the moist mountainous regions of the eastern United States, and may be regarded as a northern extension of that flora This general area also represents the eastern or Atlantic extension of the broad band of northern Canadian forested territory which links it with a region of similar ecological conditions in the western mountains and on the Pacific Coast Although very little is known of the fungous flora of the northern Canadian region, it presents conditions which undoubtedly allow the extension of a northern element of the fungous flora across the North American continent. Kauffman (12), in his studies of the fungi of the Pacific Coast, was struck by the large component of North European species in this area and says "Two mycological features impress an eastern mycologist when he enters the Pacific states west of the Cascade Range In the first place, many species, if one is at all familiar with northern European plants, are found to be old Friesian species "

clustered in small groups on a common hypothallus consisting of the very faint remains of dried slime, simple, unbranched, bearing a solitary cyst and dull yellow to brownish Cyst spherical to ellipsoid, 200–400 μ in diameter, bright yellow Rods short, 1 5–2 0 × 0 5–0 8 μ

On decayed wood infected with a Chlorosplenium mycelium Upper Brookside, August, 1931 (1513)

The writer has been unable to locate any species of Chondromyces with a yellow color, simple stalks, and solitary cysts This material might possibly be immature *Chondromyces crocatus* B & C, but there appears to be a definite wall formed about the large solitary cysts and the rods are shorter than those of *C crocatus*

MYXOMYCETES

(Unless otherwise indicated, the Myxomycetes were determined by G W Martin)

Arcyria cinerea (Bull) Pers — On decayed wood, Upper Brookside, July 18, 1931 (1084), Victoria Park, Truro, July 6, 1931 (411)

Arcyria denudata (L) Wettst — On decayed wood, Folleigh Lake, July 20, 1931 (1089)

Arcyria incarnata Pers — On decayed wood, Victoria Park, Truro, July 6, 1931 (413), New Glasgow Road, July 25, 1931 (1141), Upper Brookside, August 24, 1931 (1400)

Arcyria nutans (Bull) Grev — On decayed logs, Upper Brookside, July 17, 1931 (1079), New Glasgow Road, July 25, 1931 (1140)

*Badhamia decipiens (Curt) Berk — On beech bark, Upper Brookside, July 9, 1931 (466)

*Ceratiomyxa fruticulosa Macbr var flexuosa List — On decayed logs, Upper Brookside, July 4, 1931 (388), July 19, 1929 (133), det L E Wehmeyer

communi ex vestigio colloideo tenui consistente aggregatis, sordide luteis vel subbrunneis, cystem solitariam ferentibus, cystibus sphaericis vel ellipsoideis, diametro 200–400 μ, perluteis, bacillis brevibus, 1 5–2 0 μ longis, 0 5–0 8 μ crassis Cum mycelio *Chlorosplenii* in ligno putrido, localitate Brookside dicta, Com Colchester, Nova Scotia, legit auctor sub numero 1513 in Herb Univ Mich

A speciebus generis aliis differt colore luteo, stipitibus simplicibus et cystis solitariis, a *C crocato* B & C speciatim differt circumvallatione cystorum magnorum solitariorum definita et bacillis brevioribus.

COMATRICHA SUBCAESPITOSA Pk — On decayed wood, Salmon River region, July 14, 1931 (1029) *C nigra* is listed by Moore (16), and this is probably the same as his material

COMATRICHA TYPHOIDES (Bull) Rost — On decayed wood, Upper Brookside, July 3, 1931 (393), probably the *C stemonites* of Moore's list (16) Green Oaks, Colchester Co , July 9, 1931 (479)

*CRIBRARIA DICTYDIOIDES (Cke) Balf — On decayed wood, Victoria Park, Truro, August 23, 1929 (255)

*CRIBRARIA PIRIFORMIS Schrad — On decayed wood, New Glasgow Road, July 25, 1931 (1142)

*DIACHAEA LEUCOPODIA (Bull) Rost — On dead leaves and débris or upon living leaves of ferns, etc , Upper Brookside, September 6, 1931 (1485)

*DICTYDIUM CANCELLATUM (Batsch) Macbr — On decayed logs, Upper Brookside, July, 1929 (131), Upper Brookside, July 31, 1929 (191), Mt Thom, August 8, 1931 (1256) Common on the decorticated surfaces of well-decayed logs

*DIDERMA SPUMARIOIDES Fr — On beech bark, Upper Brookside, July 24, 1931, det L E Wehmeyer (1138), on dead leaves, Middle River, Victoria Co , Cape Breton, August 5, 1931, det L E Wehmeyer (1221)

*DIDERMA TESTACEUM (Schrad) Pers — On porcupine dung, Mt Thom, August 15, 1931, coll A H Smith (1328)

DIDYMIUM MELANOSPERMUM (Pers) Macbr — On lichens on wood, Salmon River region, July 14, 1931 (1033) (partly parasitized ?), on mosses, Salmon River region, August, 1921 (1494), on decayed leaves, Upper Brookside, July 1, 1931, det L E Wehmeyer (348) Common on deep growths of mosses and lichens, often forming striking decorations of upright moss plants such as Polytrichum

*DIDYMIUM NIGRIPES (Lk) Fr var XANTHOPUS (Ditm) List — On spruce duff, Salmon River region, August 18, 1931 (1375) Often found in great abundance on fallen cones, twigs, and needles under spruce

*ENERTHENEMA PAPILLATUM (Pers) Rost — On dead wood, Salmon River region, July 15, 1931 (1049) (Entire collections were sent to G. W Martin)

*FULIGO MUSCORUM Alb & Schw — On moss, Upper Brookside, September 1, 1931 (1486)

FULIGO SEPTICA (L) Gmel — On moss, Upper Brookside and Salmon River region, July 8–15, 1931 (450, 1028, 1052, 1053), beech log, Upper Brookside, August 1, 1929, det L E Wehmeyer (186) Common

*FULIGO SEPTICA var LAEVIS Pers — On log, Earltown Road, August 22, 1931 (1391)

HEMITRICHIA CLAVATA (Pers) Rost — On decayed log, Upper Brookside, July 27, 1929 (156) According to Martin, "This has the color and appearance of *H stipitata* (Mass) Macbr I can find no constant characters to distinguish these two species and hence at present follow Lister in regarding them as the same"

HEMITRICHIA STIPITATA (Mass) Macbr — On decayed log, Upper Brookside, July 17, 1931 (1078)

LEOCARPUS FRAGILIS Rost — On dead wood, Upper Brookside, July 16, 1931, det L E Wehmeyer (1068)

LICEA VARIABILIS Schrad — On conifer stub, Mt Thom, August 15, 1931 (1334) Deep pink flesh color at first, becoming dull olive black at maturity

LYCOGALA EPIDENDRUM Fr — On decayed fir wood, New Glasgow Road, June 30, 1931, det L. E Wehmeyer (342)

*PHYSARUM CONFERTUM Macbr — On fir twigs, Salmon River region, August 18, 1931 (1357), on moss, Salmon River region, July 15, 1931 (1051), Upper Brookside, August 13, 1931, Salmon River region, August 18, 1931 (1353) Very frequent on the thick mossy carpets under older stands of spruce and other conifers

*PHYSARUM CONTEXTUM Pers — On beech bark, Folleigh Lake, July 20, 1931 (1098)

PHYSARUM GLOBULIFERUM (Bull) Pers. — On decayed log, Upper Brookside, August 11, 1931 (1268), on porcupine dung, Mt Thom, August 15, 1931, coll A H Smith (1315)

*PHYSARUM LATERITIUM (Berk & Rav) Morgan — On wood, moss, and leaves, Mt Thom, August 15, 1931 (1339), Upper Brookside, August 24, 1931 (1399)

*PHYSARUM MUTABILE List — On leaves, Upper Brookside, September 1, 1931, det H C Gilbert (1484) "May be an aberrant form of something else," according to Martin

PHYSARUM NUTANS Pers — On decayed wood, New Glasgow Road, July 25, 1931 (1143), parasitized, New Glasgow Road, July 25,

1931 (1144), Mt Thom, August 15, 1931, det H C Gilbert (1327) Approaches *P leucophaeum* In Moore's list as *Tilmadoche alba*

*PHYSARUM PULCHERRIMUM Berk & Rav — On decayed log, Upper Brookside, July 27, 1931 (1166)

*PHYSARUM RUBIGINOSUM Fr — On moss on decayed log, Salmon River region, August 19, 1931 (1365)

PHYSARUM VIRESCENS Ditm — On moss and débris, Middle River, Inverness Co, Cape Breton Island, August 5, 1931 (1217), Salmon River region, August 18, 1931 (1358) Quite frequent

*PHYSARUM VIRESCENS var NITENS List — On mosses and lichens, Upper Brookside, July 13, 1931 (1009)

PHYSARUM VIRIDE (Bull) Pers — On decayed limbs, Upper Brookside, July 18, 1931 (1095), New Glasgow Road, July 25, 1931 (1139), Salmon River region, August 18, 1931 (1352) Very abundant and common on the decorticated surfaces of limbs and branches In Moore's list as *Tilmadoche viride*

STEMONITIS AXIFERA (Bull) Macbr — On decayed logs, both conifer and hardwood, Upper Brookside, July 19, 1929 (165), Upper Brookside, July 4, 1931 (390), Upper Brookside, July 4, 1931 (394), Upper Brookside, July 7, 1931 (423)

STEMONITIS FERRUGINEA Ehrenb — On decayed wood, Salmon River region, August 1, 1931 (1499) In Moore's list as *S Smithii*?

*STEMONITIS FLAVOGENITA Jahn — On conifer log, Upper Brookside, July 19, 1929 (39)

STEMONITIS FUSCA Roth var TRECHISPORA Torrend — On decayed beech, Upper Brookside, July 7, 1931 (425), on moss, Mt Thom, August 15, 1931 (1335) This variety with reticulate spores is the same as the *S maxima* given in Moore's list

TRICHIA PERSIMILIS Karst — On decayed wood, Killag Mines, Halifax Co, July 30, 1931 (1190)

TUBIFERA FERRUGINOSA (Batsch) Macbr — On decayed logs and stumps Victoria Park, Truro, July 6, 1931 (410), Mt Thom, August 15, 1931 (1340), Salmon River region, August 18, 1931 (1407)

PHYCOMYCETES

ALBUGO CANDIDA (Lev) O Kuntze — On *Dentaria diphylla*, Upper Brookside, May 22, 1928 (16), coll A R Prince (6005)

*BREMIA LACTUCAE Regel — On *Lactuca* sp , Mt Thom, August 15, 1931 (1318)

*ENDOGONE PISIFORMIS Link — On tips of Sphagnum, forming large globose to irregularly convoluted, orange-yellow, waxy masses of zygospores New Glasgow Road, June 30, 1931 (341)

*MUCOR HIEMALIS Wehmer — From moose dung, Killag Mines, Halifax Co , July 30, 1931, and cap of *Mycena haematopa*, Folleigh Lake, August 29, 1931, coll A H Smith (1434) This species was obtained from gross cultures of the collections given The spores were quite variable, they are broad-ellipsoid to oblong, (3 5) 4-6 5 × (2) 2 5–4 μ

*PILOBOLUS LONGIPES Tiegh – On horse dung, Upper Brookside, July 15, 1929 (49), Killag Mines, Halifax Co , July 30, 1931 (1180) No 49 was collected in the evening, when the young sporangiophores were deep orange-yellow and formed a turf over the entire surface By morning the maturing sporangiophores were all hyaline, with the black terminal, lenticular sporangia measuring 150–300 μ in diameter and 100-200 μ in thickness

SPORODINIA GRANDIS Link — On *Inocybe* sp and *Boletus scaber*, Upper Brookside, July 1, 1931 (347), on *Amanita flavoconia*, Upper Brookside, July, 1929 (103) Common on caps of agarics and Boleti

BASIDIOMYCETES

USTILAGINALES

SPHACELOTHECA HYDROPIPERIS (Schum) De Bary — On *Polygonum sagittatum*, Earltown Road, August 19, 1931 (1366)

UREDINALES

(Unless otherwise indicated, all the rusts were determined by E B Mains)

CALYPTOSPORA GOEPPERTIANA Kühn — On *Vaccinium* sp , Folleigh Lake, July 20, 1931 (1264)

CHRYSOMYXA LEDICOLA Lagerh — On *Picea rubra*, Pug Lake, Shelbourne Co , August 15, 1929 (10), coll A R Prince (6023), on

Picea mariana, Killag Mines, Halifax Co, July 30, 1931 (1177), on *Picea sp*, Salmon River region, July 3, 1931, coll A H Smith (414), on *Ledum groenlandicum*, Victoria Park, Truro, June 24, 1929 (20)

CHRYSOMYXA PIROLATUM Wint — On cone of spruce, Folleigh Lake, July 20, 1931 (1104)

COLEOSPORIUM SOLIDAGINIS (Schw) Thüm — On Solidago, Upper Brookside, July 28, and August 28, 1931 (1258, 1258a), on Aster, Onslow, August 31, 1931 (1449) Abundant

CRONARTIUM RIBICOLA Fisch — On *Pinus Strobus*, Kentville Experiment Station, May, 1917, coll J F Hockey (90) On *Ribes nigrum*, Upper Brookside, July 27, 1929 (144), Pictou Landing, Pictou Co, August 12, 1928 (40), coll A R Prince (6026), on *Ribes vulgare*, Upper Brookside, July 27, 1929 (164), on *Ribes sp*, Upper Brookside, July 28, 1931 (1259)

FROMMEA OBTUSA (Strauss) Arth — On *Potentilla canadensis*, Upper Brookside, July 28, 1931 (1260)

GYMNOCONIA INTERSTITIALIS (Schlecht) Lagerh — On *Rubus sp*, Upper Brookside, May 22, 1927 (13), coll A R Prince (6018), S Maitland, Hants Co (2), coll A R Prince (6033) Common on Rubus in early summer The aeciospores were not germinated to test for the possibility of the presence of *Kunkelia nitens*

*GYMNOSPORANGIUM CLAVARIAEFORME (Jacq) DC — On *Juniperus communis*, Kentville, Kings Co, July 29, 1927, coll J F Hockey (112)

Roestelia lacerata, the aecial stage of this species, is reported from Nova Scotia by MacKay (14, p 141) Fraser (9, p 391) also reports on Amelanchier a Roestelia which he says may be the aecial stage of either this or the following species So far as the writer is able to determine, these collections are the only reports of the telial stage of the genus Gymnosporangium from the Province

*GYMNOSPORANGIUM CLAVIPES Cke & Pk — On *Juniperus communis*, Kentville, Kings Co, July 29, 1927, coll J F Hockey (123)

MELAMPSORA BIGELOWII Thüm — On *Salix sp*, Victoria Park, Truro, July 22, 1931 (1112)

MELAMPSORA HUMBOLDTIANA Speg — On *Salix sp*, Upper Brookside, July 27, 1931 (1511)

MELAMPSORELLA CARYOPHYLLACEARUM Schröt — On *Abies balsamea*, Upper Brookside, June 30, 1927 (71), coll A R Prince (6048), Apple River, Cumberland Co, July 18, 1928 (22), coll A R Prince (6008), Victoria Park, Truro, June 24, 1929 (1) Quite abundant locally, causing the conspicuous yellow-foliaged witches'-broom on fir

PHRAGMIDIUM AMERICANUM Diet — On *Rosa sp*, Upper Brookside, August 7, 1929, and June 26, 1931 (198, 296), marsh, Onslow, August 31, 1931 (1449)

PUCCINIA ANGUSTATA Pk — On *Scirpus rubrotinctus*, marsh, Onslow, August 31, 1931 (1450), on *Scirpus pedicellatus*, Upper Brookside, July 27, 1931 (1158), on *Scirpus sp*, Truro, September 3, 1929 (271)

*PUCCINIA ARENARIAE (Schum) Wint — On *Arenaria peploides*, Pictou Beach, Pictou Co, July 22, 1931 (1114) "Apparently a new host," according to Dr Mains

PUCCINIA ASTERIS Duby — On *Aster macrophyllus*, Upper Brookside, July 24, 1929 (147) and July 6, 1931 (461), Mt Thom, August 15, 1931 (1512), *Aster sp*, Salmon River region, July 3, 1931 (454)

PUCCINIA CICUTAE Lasch — On *Cicuta maculata*, Onslow, August 31, 1931 (1442)

PUCCINIA CIRCAEAE Pers — On *Circaea sp*, Mt Thom, August 15, 1931 (1453)

PUCCINIA EXTENSICOLA Plowr — On *Solidago sp*, Upper Brookside, June 22, 1928 (77), coll A R. Prince (6014), July 27, 1931 (1261), New Glasgow Road, June 30, 1931 (456), on *Aster acuminatus*, Upper Brookside, June 27, 1931 (298) Abundant on Aster and Solidago

PUCCINIA FRASERI Arth — On *Hieracium scabrum*, Upper Brookside, June 28, 1931 (460), on *Hieracium sp*, Upper Brookside, May 22, 1922 (12), coll A R Prince (6009), Truro, May 16, 1928 (50), coll A R Prince (6027)

PUCCINIA GRAMINIS Pers — On *Agrostis alba*, marsh, Onslow, August 31, 1931 (1451), on *Phleum pratense*, Upper Brookside, August 11, 1931 (885), on *Poa sp*, Upper Brookside, July 28, 1931 (1168)

PUCCINIA GRINDELIAE Pk — On *Solidago sp*, Victoria Park, Truro, August 8, 1929 (248)

PUCCINIA HIERACII Mart — On Hieracium, Upper Brookside, July 27, 1929 (130), on Taraxacum, Upper Brookside, June 14, 1929 (136), July 28, 1931 (1169), marsh, Onslow, August 31, 1931 (1169a)

PUCCINIA IRIDIS Rab — On *Iris sp*, Onslow, August 31, 1931 (1441), Salmon River region, August 1, 1931 (1199)

PUCCINIA ORNATA Arth & Holw — On *Rumex* (*britannica*?), marsh, Onslow, August 31, 1931 (1438)

PUCCINIA PRINGSHEIMIANA Kleb — On *Carex sp*, Wentworth Valley, Cumberland Co, August 29, 1931 (1482)

PUCCINIA PUNCTATA Link — On Galium, Upper Brookside, July 28, 1931 (1257)

PUCCINIA RUBIGO-VERA (DC) Wint — On *Agropyron repens*, Upper Brookside, June 29, 1931 (459)

PUCCINIA SESSILIS Schneid — On *Maianthemum canadense*, Upper Brookside, July 1, 1931 (455)

PUCCINIA VIOLAE (Schum) DC — On *Viola cucullata*, Upper Brookside, June 15, 1927 (122), on *Viola sp* Evangeline Beach, Wolfville, June 26, 1926 (29), coll A R. Prince (6016), marsh, Onslow, August 31, 1931 (1446)

PUCCINIASTRUM AGRIMONIAE (Diet) Transch — On *Agrimonia sp*, Truro, August 31, 1929 (264)

PUCCINIASTRUM PYROLAE (Karst) Schröt — On *Pyrola elliptica*, Upper Brookside, June 22, 1926, and July 7, 1929 (76, 138), Upper Brookside, June 28, 1931 (452)

PUCCINIASTRUM VACCINIORUM (Karst) Dietel — On *Tsuga canadensis*, Victoria Park, Truro, July 22, 1931 (1111) On *Rhododendron canadense*, Upper Brookside, July 28, 1931 (1170)

TRANSCHELIA THALICTRI (Chev) Dietel — On *Thalictrum polygamum*, Onslow, August 31, 1931 (1443)

UREDINOPSIS AMERICANA Syd — On *Abies balsamea*, Upper Brookside, July 18, 1926, and September 5, 1928 (17, 55), coll A R Prince (6006, 6206), August 14, 1931 (1337), Killag Mines, Halifax Co, July 30, 1931 (1183) On *Onoclea sensibilis*, Upper Brookside, August 11, 1931 (1274), Wentworth Valley, Cumberland Co, August 29, 1931 (1274a)

UREDINOPSIS OSMUNDAE Magn — On *Osmunda cinnamomea*, Upper Brookside, August 11, 1931 (1273), on *Osmunda Claytoniana*, Mt Thom, August 10, 1931 (1273a)

Uredinopsis Phegopteridis Arth — On *Phegopteris sp*, Salmon River region, August 1, 1931 (1200)

Uredinopsis Struthiopteridis Stormer — On *Onoclea Struthiopteris*, Upper Brookside, August 12, 1931 (1281)

Uromyces acuminatus Arth — On *Spartina Michauxiana*, marsh, Onslow, August 31, 1931 (1439)

*Uromyces appendiculatus Link — On *Phaseolus vulgaris*, Mill Village, Queens Co, August 5, 1927, coll and det A R Prince (114)

Uromyces Arisaemae Cke — On *Arisaema trifolia*, Upper Brookside, June 15, 1927 (115)

Uromyces Fabae (Pers) De Bary — On *Vicia Cracca*, Onslow, August 31, 1931 (1444)

Uromyces perigynius Halstead — On *Carex scoparia*, Upper Brookside, July 27, 1931 (1157)

Uromyces Poae Rab — On *Poa trivialis*, Upper Brookside, July 10, 1931 (1266) The first report of this species from America was by Fraser (9, p 373), who found it on *Ranunculus repens* and *Poa trivialis* near Pictou in 1910 Arthur (*North Am Flora*, 7 750) reports it from Vermont and Alberta also The present collection was found some forty miles from the original station

Uromyces Trifolii (Hedw f) Lév — On *Trifolium pratense*, Truro, September 21, 1929 (253), on *T repens*, beach, St Peters, Richmond Co, Cape Breton Island, August 3, 1931 (1510a), *Trifolium sp*, Upper Brookside, July 28, 1931 (1510), marsh, Onslow, August 31, 1931 (1445)

Uromyces triquetrus Cke — On *Hypericum sp*, Upper Brookside, July 13, 1931 (1265)

Auriculariaceae

Auricularia auricula-Judae (L) Bull — On stubs and limbs of *Abies balsamea*, New Glasgow Road, June 30, 1931 (336), Earltown Road, August 19 and 26, 1931 (1367, 1367a) Fairly common on dead coniferous wood

Eocronartium muscicola (Fr) Fitzp — Parasitic upon the growing tips of *Drepanocladus uncinatus* (Hedw) Warnst, Upper Brookside, July 1, 1933 (1567)

TREMELLACEAE

EXIDIA GLANDULOSA (Bull) Fr — On Fagus, Upper Brookside, June 29, 1931, and July 18, 1929 (324, 55), on Alnus, Victoria Park, Truro, October 19, 1926 (91), coll A R Prince (1003?) Common, especially on beech

*EXIDIA NUCLEATA (Schw) Burt — On Acer, Earltown Road, August 19, 1931 (1359) Burt (3, p 372) gives *E spiculata* as being darker, thicker, and more rugose than *E nucleata* and as drying fuscous black This collection, when fresh, showed a variation from gray or violaceous tints through red browns, as does *E spiculata* When fresh, it was pulvinate to rugose and as much as 5 mm thick, but it dried down to a faint red-brown crust

*GYROCEPHALUS RUFUS (Jacq) Bref — On decayed wood, Upper Brookside, July 18, 1931, coll A H Smith (1077), on soil, Upper Brookside, August 13, 1931 (1077a)

*NAEMATELIA ENCEPHALA (Wild) Quél — On *Abies balsamea*, Mt Thom, August 15, 1931 (1332)

*SEBACINA INCRUSTANS (Pers) Tul — Encrusting base of fern fronds, Middle River, Victoria Co, Cape Breton Island, August 5, 1931 (1230), on exposed roots of trees, Upper Brookside, August 12, 1931 (1230a)

*TREMELLA ATROVIRENS (Fr) Sacc — On old sphaeriaceous stromata on Salix, Upper Brookside, July 16, 1931 (1059) Fruit bodies small, pulvinate, 0 8–3 mm in diameter, smooth or slightly roughened or gyrose, scattered, grouped, or confluent, deep yellow- or olive-brown at first, becoming black G W Martin, who examined the specimen and suggested that it is this species, which has not so far been reported from America, gives me the following data by letter "Basidia 2- or 4-celled I have seen no attached basidiospores, but there are many globose spores which I take to be basidiospores, mostly 5–6 μ in diameter but ranging from 4–7 μ"

*TREMELLA FOLIACEA (Pers) Fr — On *Abies balsamea*, St Peters, Richmond Co, Cape Breton Island, August 3, 1931 (1233), Earltown Road, August 22, 1931 (1233a) Both these collections on conifers were small, 2 3 cm in diameter, and brownish violet, and are apparently var *violescens* Alb & Schw

TREMELLA LUTESCENS (Pers) Fr — On *Cornus alternifolia*, Upper Brookside, July 16, 1931 (1057), on Fagus, Upper Brookside, July 25, 1929 (92), and on Acer, Upper Brookside, July 13, 1929 (117)

*TREMELLA MYCETOPHILA Pk — On *Collybia dryophila*, Mt Thom, August 15, 1931 (1309) Regarded by some as an aberrant growth form of the Collybia

*TREMELLODENDRON CANDIDUM Berk & Curt — On soil, Earltown Road, August 22, 1931 (1500), Upper Brookside, September 4, 1931 (1501), Mt Thom, August 11, 1927 (11), coll A R Prince (6163)

*TREMELLODENDRON MERISMATOIDES (Schw) Burt — On soil, Upper Brookside, August 24, 1931 (1502)

*TREMELLODENDRON PALLIDUM (Schw) Burt — Under hardwoods, Mt Thom, August 15, 1931 (1320)

TREMELLODON GELATINOSUM (Scop) Fr — On dead wood, Middle River, Victoria Co , Cape Breton Island, August 5, 1931 (1215)

DACRYOMYCETACEAE

*CALOCERA CORNEA (Batsch) Fr — On Fagus, Upper Brookside, July 11, 1931 (488), on Betula, Folleigh Lake, July 20, 1931 (488a) On Betula there is sometimes a flattening or a slight branching of the apex of the fruit bodies, but for the most part these are simple

*CALOCERA PALMATA (Schum) Fr — On *Abies balsamea*, Folleigh Lake, July 20, 1931 (488b), on conifer wood, Mt Thom, August 15, 1931 (488c) These collections on conifers show a much greater branching of the fruit bodies The spores (9 5–12 × 4 5–5 μ and 9–11 × 2 5–4 μ) are also slightly larger than those of *C cornea* on hardwoods (8 5–10 × 3 5–4 5 μ). No 488b is somewhat intermediate between these two species, with a flattening and branching of the tips, but 488c is richly branched and up to 1 5 cm tall, resembling a small Clavaria These specimens are too small for *C viscosa* and do not have the rooting base of that species They might be placed in *C furcata* Fr , which occurs on conifers, but seem more likely to be *C. palmata*, which is probably an extension of the range of variation of *C cornea*

Dacryomitra ramosa, sp nov[1] (text Fig 3) — Gelatinous fruiting heads one or more, 2-6 mm in diameter, flattened, disklike at first, becoming confluent and convoluted, sometimes sessile, but generally upon a well-developed stalk, orange-colored Stalk 1-8 mm in length, yellowish white, slightly pubescent, more fleshy than the hymenophore, usually tapered toward a pointed base and branching above into 2-3 short, stout branches which bear the hymenial heads Stipe 3-5 mm in diameter at the point of branching Basidia 50-60 × 4-5 μ, sterigmata varying

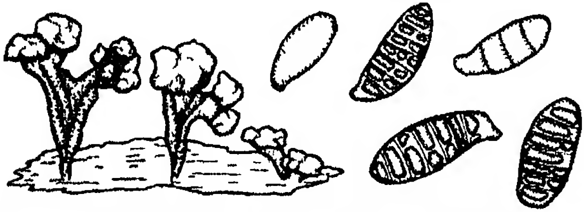


FIG 3 Habit of fruiting bodies (left) and spores of *Dacryomitra ramosa*

up to 32 μ in length Spores ellipsoid or somewhat curved, apiculate, hyaline, and one-celled at first, becoming 8-celled and somewhat yellowish at maturity Septate spores were seen budding off minute secondary conidia, which were bacillar and measured 1 5-3 0 × 1 0 μ Some spores also seen with germ tubes Spores 15-24 × 6 5-8 5 μ

In general form this species seems to approach most closely *Dacryopsis nuda* Massee, which, however, has 3-septate, smaller spores If the genus Dacryopsis is recognized, this species might

[1] **Dacryomitra ramosa**, sp nov — Capitula aurantiaca gelatinosa, 2-6 mm diam , interdum sessilia, sed saepissime distincte stipitosa, iuventate disciformia, depressa, aetate confluentia, convoluta Stipes 1-8 mm longus, albide luteus, subpubescens, textura carnosior quam hymenophorum, plerumque versus basim acutam angustatus, infra furcationem 3 5 mm crassus, sursum ramosus, ramis 2 vel 3 brevibus, validis, apice capitula singula vel plura hymenialia ferentibus Basidia 50-60 μ longa, 4-5 μ crassa, sterigmatibus 32 μ non excedentibus Sporae 15-24 μ longae, 6 5-8 5 μ crassae, ellipsoideae vel curvatae, apiculatae, unicellulae vel demum 8-cellulae et sublutescentes, aut germinatione tubum proferentes aut conidia ferentes Conidia minuta secondaria ex sporis septatis germinatione derivata bacillaria, 1 5-3 0 μ longa, 1 0 μ crassa In trunco effeto conifero, prope "Middle River," in Com. Victoria, Cape Breton Island, Nova Scotia, legit auctor Specimina typica in Herb Univ Mich et in collectione auctoris conservata sunt

better come within it, but inasmuch as the distinctions between these two genera are not well understood, the older and more broadly defined generic name is used

G W Martin, after a study of this material, has suggested that it might be a stipitate form of *Dacryomyces palmatus* (Schw) Bres It is true that the spores are identical with those of *D palmatus*, which does sometimes have a somewhat developed stalklike base, whereas this species is also occasionally almost sessile On the contrary, the stalks of *D ramosa* are much more strongly developed than those of *D palmatus* and the hymenophore is flattened and disklike, but never flabelliform The fertile gelatinous portions are more like the sessile fruiting bodies of *D abietinus* (Pers) Schröt , which also has identical spores, but no stalk whatever It may be that further material will prove that these characters of hymenophore development and stalk production are extremely variable, but this collection differs to such an extent from both *Dacryomyces palmatus* and *D abietinus* that it is best considered a separate species

Dacryomyces deliquescens (Bull) Duby — On beech log, Upper Brookside, July 11, 1931 (487) There has been a great deal of confusion in regard to this species As defined by Rea and Bourdot and Galzin, it probably represents a species complex with a range of variation including both it and the following species The collections from Nova Scotia, however, revealed two distinct species within this range of variation One, usually on conifers, was identical with Burt's interpretation (3, p 382) of *D deliquescens*, a second, usually on hardwoods, answered the following description Fruiting bodies yellow to orange, 2–10 mm in diameter (sometimes hyaline or light yellow on under side of log), disk-shaped or becoming definitely wrinkled to gyrose A slight whitish foot in the center of the under side, but no definite rooting base Spores curved, lacrymose, apiculate, hyaline to pale yellowish, one-celled, becoming four-celled, 12 5–15 5 × 5–6 μ In a recent paper Miss Fisher (8, p 117) interprets this second species as *D deliquescens* and relegates the one which Burt interpreted as *D deliquescens* to *D minor* Peck Since this seems to be the correct interpretation of these two species, it is here adopted

Dacryomyces minor Pk — On decorticated spruce, Upper Brook-

side, June 28, 1931 (311), on Abies, Upper Brookside, June 28, 1931 (312), Killag Mines, Halifax Co, July 20, 1931 (311a) This species is often found as gregarious or confluent fruiting bodies extending for some distance along decorticated stubs of conifers The fruiting bodies are small (1–2 5 mm) and pulvinate and range in color from white to dirty or smoky yellow or dull orange The spores are lacrymose, curved, hyaline, 12–15 × 4 5–6 μ, and one-celled at first, becoming 1–3-septate at maturity

DACRYOMYCES PALMATUS (Schw) Bres — On *Acer spicatum*, Upper Brookside, July 18, 1931 (1083)

DITIOLA RADICATA Fr — On Abies, Upper Brookside, September 3, 1931 (1466) Although not on decorticated stems and with spores somewhat larger than the sizes given by Bourdot and Galzin and Lloyd (*Mycol Notes*, 64 990), this is apparently *D radicata* Fries The fruiting bodies are erumpent through the bark, short-stalked, pezizoid or irregular in shape, 0 5–2 cm in diameter, sometimes in groups of 2–3 and pale yellow at first, becoming darker at maturity The margin is usually white, smooth or slightly wrinkled, and the stem and the under side of the pileus are minutely white floccose-tomentose The superior hymenial layer is rather fleshy and distinct, particularly in cross-section of the dried plant The flesh is tough-gelatinous, and whitish translucent throughout Stems stout, 2–6 × 3–6 mm Spores ellipsoid with a curved apiculus, hyaline becoming pale yellowish, granular, nonseptate, and 16–19 × 7 μ On drying, the plants retain their shape and firm texture, and the hymenial surface is bright yellow in contrast to the dried plants of *Femsjonia luteoalba*

*FEMSJONIA LUTEOALBA Fr — On Betula, Upper Brookside, September 5, 1931 (1466a), on Fagus, Salmon River region, September 7, 1931 (1466b) This species was seen in an immature condition in the woods for some time before mature material was collected, in the first week in September When immature, with the spores still nonseptate, it is similar to *D radicata* as found on fir The mature and dried plants, however, show distinct differences The fruiting bodies of *F luteoalba* are borne singly or in clusters and are then often confluent The stem and the under side of the pileus may be whitish floccose-tomentose at first, but not

at maturity The pilei are 2–5 cm in diameter and 1 5 cm in thickness The spores are ellipsoid, with a curved apiculus, hyaline and one-celled at first, finally becoming pale yellowish, granular and 9 12-septate, and measuring 20–28 × 8 5–10 5 μ The fruiting bodies are larger and more homogeneously gelatinous than those of *D radicata*, and the spores are larger and many-septate at maturity When dry, the fruiting bodies collapse to a thin, horny, red-brown to orange stratum, which condition is quite distinct from that of dry *D radicata*

Exobasidiaceae

*Exobasidium Vaccinii (Fck) Wor — On *Vaccinium sp*, Victoria Park, Truro, June 26, 1933 (1540)

Clavariaceae

The genus Clavaria is quite abundant, in both species and individuals, in Nova Scotia Inasmuch as certain species show a great deal of variation and as authors express differences of opinion about the specific ranges, careful field notes were made of all these collections The following list presents only a preliminary survey of this genus, and until more extensive field studies can be undertaken in order to delimit specific variations, some collections in the more difficult sections must be placed more or less arbitrarily

Clavaria mucida Pers var Curtisii Berk — On decayed wood with a coating of algae, Salmon River region, August 1, 1931 (1203), September 7, 1931, coll A H Smith (1203a) This little white form with simple clubs is always associated with an algal crust on the wood and is supposed by some writers to be lichenicolous.

*Clavaria subfalcata Atk — On bare soil, Upper Brookside, September 4, 1931 (1469) Plants small, 1 5–3 cm tall, 1–1 5 mm in diameter, growing singly or in small clusters, simple, cylindric, pointed at the apex, often somewhat thickened above the middle Color variable, from "primuline yellow" through paler shades to a creamy white in many plants, and in one plant pure white Stem distinct, shiny, and, in paler plants, a darker yellow than the club Spores globose to subglobose, somewhat narrowed toward one end, hyaline, smooth, 6–7 × 5–6 μ All basidia seen were 2-spored These plants are difficult to place They

have spores similar to those of *C appalachiensis*, but are smaller, they are without the long striate clubs and occur on soil instead of wood They approach *C acuta*, but have smaller spores and are usually yellow Their spores differ from those of nearly all the simple yellow species, but as a whole they seem to approach most closely to *C subfalcata* The 2-spored basidia suggest *C fuscata*, but no garlic-like odor was detected

*Clavaria gracillima Pk (Pl LI, Fig 1) — On decayed or buried wood, Upper Brookside, August 14, 1931 (1305), September 4, 1931 (1305a), Salmon River region, September 7, 1931 (1305b) Between "pale orange-yellow" and "orange-buff" to "deep chrome," 1 5–4 cm tall, stipe 0 5–1 mm in diameter, fertile tip 1–2 mm in diameter Fertile tip tough-fleshy, elastic, distinct from the stipe, which is more fibrous and shining yellow Tip acute Flesh yellow, hymenial layer lighter in color Basidia 4-spored, 7–9 μ in diameter Spores ellipsoid, apiculate, hyaline, minutely asperulate (at least mature spores), 7–8 5 × 3 5 μ This species has apparently been known only from Peck's type, to which these collections conform in all respects Although often found among mosses, as Peck says, the clubs were always attached to buried wood or sticks The fertile tips dry a dull yellow or tan, the stipes a more shining yellow or, often, a reddish yellow above

*Clavaria rufipes Atk — On decayed leaves, Mt Thom, August 15, 1931 (1314) The spores (3 5–4 × 2–2 5 μ) were somewhat smaller than the measurements given by Coker and Atkinson, perhaps because of immaturity

*Clavaria pulchra Pk — On the ground under mixed woods, Mt Thom, August 15, 1931, coll A H Smith (1312), Earltown Road, August 19, 1931 (1312a) Young plants of collection No 1312 show what appear to be conidia Long slender hyphae (1–1 5 μ in diameter) grow out through the hymenial layer to a distance of 20–30 μ and cut off from their apices numerous oblong-cylindric conidia, which are hyaline and measure 4–11 × 1 5–2 μ Typical basidiospores were found in these same hymenia and the plants appear normal in all respects, showing no indication of parasitism

The three species, *C pulchra*, *C aurantio-cinnabarina*, and *C fusiformis*, include a closely related series of forms There is

a good deal of variation in color, size, structure, and grouping of the clubs, but the three can easily be separated by spore characters and certain other correlated distinctions *C fusiformis* tends to have more densely fasciculate groups of clubs, which are usually hollow and remain various shades of light yellow upon drying, only the tips turning a resinous reddish brown The spores are globose, with a central apiculus, and measure 5 6 5 × 4 5-6 μ In both *C pulchra* and *C aurantio-cinnabarina* the clubs are less densely fasciculate, usually solid and in drying turn a resinous reddish brown all the way, or almost, to the base *C pulchra* is bright yellow to chrome and has oblong spores, flattened on one side, 5 5 7 × 3 5-4 5 μ, with an excentric apiculus *C aurantio-cinnabarina* has orange to reddish fruiting bodies and the spores are more subglobose, 5 5-7 × 4 5-5 μ, with an excentric apiculus

*CLAVARIA AURANTIO-CINNABARINA Schw — On ground in mixed woods, Earltown Road, August 21, 1931 (1360a) A collection lost in transit showed certain marked deviations from the characters of *C aurantio-cinnabarina* The tips were lighter yellow when young, the spores were markedly triangular, with an apiculus at one angle, and the hymenium contained dark reddish brown conducting organs 3 5-7 μ in diameter This may have represented a new species The spores were 6-7 × 4-5 2 μ The second collection showed similar characters but not in so marked a degree

CLAVARIA FUSIFORMIS Sower (Pl LII, Fig 2 *a*) — On soil under conifers and mixed woods, Upper Brookside, July 24, 1931, coll A H Smith (1132), Mt Thom, August 10, 1931 (1132a), Earltown Road, August 19, 1931 (1132, b-d), Economy River, August 31, 1927 (34), coll A R Prince (6213, 6254), Wabi Lake, Shelbourne Co, August 31, 1928, coll A R Prince (6114), Westcook's Cove, Guysborough Co, September 6, 1925, coll A R Prince (1158) This is probably the most common of these three species

CLAVARIA VERMICULARIS Fr — On soil under woods, Upper Brookside, August 18, 1931 (1086), August 23, 1931 (1086a) Clubs simple, fasciculate at the base, tapering upward and downward, pure white, cylindrical, hollow, 4-9 × 0 2-0 5 cm Spores ovoid, smooth, hyaline, 4 5-5 5 × 3 5 μ In the later collection (1086a)

the clubs were pinkish tan, the tips collapsed, dirty brown, and the spores were somewhat larger, 6 7 × 2 5 3 5 μ In this condition these plants might well be interpreted as the flesh-colored form of *C helveola* (*C incarnata* Weinm) or *C rosea* Dalm , as described by Coker (4, pp 38, 39, 40)

*CLAVARIA PURPUREA Fr emend Kauffm — On soil under conifers, Salmon River region, August 18, 1931 (1345), August 24, 1931 (1345a) Gregarious, clubs simple, single or cespitose, young plants "light grayish vinaceous" toward tips, lighter creamy toward base Older plants "pale ochraceous-buff" to "pinkish buff," often with shades of pale amethyst ("light vinaceous-gray") Tips soon shrinking and becoming dirty grayish brown Base whitish tomentose Clubs 3–12 cm tall, 1 5-5 mm thick, fleshy-fibrous, brittle, fusiform, straight or sinuous, hymenium often peeling away, stuffed, becoming hollow Odor none , taste none or faintly fishy Basidia 4-spored, 6-7 μ in diameter Spores ellipsoid, hyaline, smooth, slightly apiculate, often inequilateral or curved, 5 5-7 × 3 4 μ Some giant spores, 8 10 × 4–5 μ, were also seen on 4-spored basidia of No 1345a The hymenium is thickly studded with stout, hyaline, cylindric cystidia, which are 45–60 × 7-9 μ Kauffman (13, p 143) has pointed out that specimens of *C purpurea* in Sydow, Myc Germ No 1833, although similar in all other respects to *C fumosa*, show large cylindrical cystidia in the hymenium These specimens agree very well with Kauffman's emended description of this species At the same time Kauffman described a second species, *C fumosoides*, from Quinault, Washington, which differed in its smaller spores (7–9 (10) × 3 5–4 5 μ in *C purpurea* and 5–6 (7) × 3 5 μ in *C fumosoides*) and its occurrence in open fields instead of in fir woods The writer's collections have the small spores of *C fumosoides*, but were found in spruce and fir woods It is also interesting to note that giant spores, similar to those of *C purpurea*, occurred in one of the specimens An examination of Kauffman's type of *C fumosoides* shows the spores to be 6–8 × 3–4 μ The spores of Sydow's specimen are slightly larger (7 5–9 2 × 3–4 5 μ), but there is not sufficient distinction for specific separation In view of these facts it seems that *C fumosoides* should be regarded as a synonym, or at most a habitat form of *C purpurea* Fr

Clavaria ligula Schaeff (Pl LII, Fig 1) — Under conifers, Salmon River region, August 13, 1931 (1297), Upper Brookside, August 4, 1931 (1297b), August 20, 1931, coll A H Smith (1297a), September 5, 1931, coll A H Smith (1297c) Occurring locally but gregarious and in large troops in coniferous woods

Clavaria pistillaris L — On soil under hardwoods, Upper Brookside, August 27, 1931, coll A H Smith (1417), Folleigh Lake, August 29, 1931, coll A H Smith (1417a) These specimens, here referred to *C pistillaris*, were elongate-clavate, somewhat, but not abruptly, swollen above The spores were 8 5 9 5 × 5–7 5 μ

*Clavaria muscoides L — On soil, Earltown Road, August 19, 1931 (1363), on old stump, Earltown Road, August 22, 1931 (1388) Specimens without the rank farinaceous taste mentioned by Coker, spores globose to subglobose, smooth, hyaline, 5–7 × 5–6 μ

*Clavaria (Lachnocladium) ornatipes Pk — On mossy bank under hardwoods, Lake O'Law, Inverness Co, Cape Breton Island, August 5, 1931 (1218)

*Clavaria lavendula Pk — On soil under hardwoods, Salmon River region, August 18, 1931, coll A H Smith (1347) Deep amethyst violet ("argyle purple" to "Bishop's purple"), 4–5 cm tall, cespitose with the bases more or less fused, fleshy, very brittle Clubs erect, sinuous, terete to somewhat flattened, surface rugose, simple or with 2–3 branches or with short obtuse branches at the apex, 1–4 mm in diameter, bases lighter, gray to cinereous Odor slight, taste slightly farinaceous Tips dried, brown, hairlike Spores ellipsoid, hyaline, flattened on one side, 5–6 × 3 5–4 μ Coker (4, p 90) considers this species a synonym of *C amethystina* There is confusion in regard to the interpretation of *C amethystina* and a wide variation in spore measurements is given for it (see Bourdot and Galzin, p 107) Since Peck's description and spore measurements for *C lavendula* fit our plant very closely his name is retained for these collections

*Clavaria crocea Pers — On leaf mold, Earltown Road, August 18, 1931, coll A H Smith (1361) 1–2.5 cm tall, deep orange-chrome, main stalk long and slender, up to one centimeter Branching regular, dichotomous, 3–4 times, open Tips blunt,

2-pronged Spores globose, hyaline, 2 5–3 5 μ in diameter Taste bad, odor none A very beautiful little plant in fresh condition

*CLAVARIA SUBTILIS Pers (?) *sensu* Oudemans — On moss or humus, Earltown Road, August 21, 1931 (1379), August 22, 1931 (1379a) Small, 1–2 cm tall, pure white, occasionally simple but usually branched 1–3 times in an antler-like fashion Primary stalk 5–12 mm long, 0 5 1 mm thick, secondary branches dichotomous or fascicled, often flattened, 0 2–1 mm thick, angles rounded giving an open branching Tips concolorous Base sometimes slightly darker Spores subglobose, hyaline, smooth, 3–3 5 × 2–3 μ These plants have the build of *C crocea* but are white They might be mistaken for young plants of *C Kunzei*, having spores and texture similar to those of that species but showing certain differences as follows These plants are single with a definite primary stalk 5 12 mm long and usually few, comparatively fine (0 2 0 5 mm thick) open branches, whereas *C Kunzei*, even in young plants, is fasciculate, branching from the ground line and with main branches 1 5 mm in diameter and with even the secondary branches or tips 0 6–2 mm in diameter

This species seems to be either the *C subtilis* or *C macropus* of Persoon (20, p 51) In his figure (Pl I, Fig 2), he shows two plants with two names in vertical column If the upper name (*C subtilis*) refers to the left-hand figure, this species resembles *C cristata*, and the right-hand figure (*C macropus*) resembles our plant Coker (4, p 95), however, states that Fries' interpretation of *C macropus* (based on specimens collected by Fries and deposited at Kew) would place it as a synonym of *C cristata* Coker gives *C subtilis* as a doubtful synonym of *C Kunzei* Renouf (21) and Bourdot and Galzin (2) describe the spores of both *C subtilis* and *C macropus* as oblong to subglobose and larger than in our plants There are several descriptions of *C subtilis* in the literature, however, which fit our plants very well That of Oudemans (19, p 674) follows "Espèce terrestre, naine, simple ou rameuse (une ou deux fois bifurquée), à tige et rameux grêles, blancs ou grisâtre-pâle, atteignant à peu près le même niveau Spores incolores, 2 à 3 5 μ en diam Hauteur de nos exemplaires 1 à 2 cent,

épaisseur ½ à 1½ mill" This conforms to the plant referred to by Cotton and Wakefield (5, p 196) as a slender white to pale yellow species which would pass for the *C subtilis* of Rea except for the subglobose spores, 3 μ in diameter Our plants are therefore referred to *C subtilis* as interpreted by these authors

CLAVARIA KUNZEI Fr (Pl LII, Fig 2 c) — On much-decayed wood or soil, Mt Thom, August 10, 1931, coll A H Smith (1250), Upper Brookside, August 14, 1931 (1250a) Pure snow-white, sometimes with yellowish discolorations toward the base, 2 4 cm tall, clustered Fragile, fleshy, but somewhat elastic, breaking up at the base into several stout main branches, 2–4 mm in diameter Branches somewhat flattened or expanded upward, in groups of 2–4, ascending at a wide curving angle giving an open, stout branch system Ultimate tips short, stout, pointed, numerous Basidia four-spored, 4–4 5 μ in diameter Spores hyaline, globose, minutely echinulate, 2 5–3 (3 5) μ in diameter Taste none, odor slight

These plants often had a much more flattened and cristate branching system than those shown in Coker's figure (4, Pl 29), as is apparent by a comparison with Plate LII, Figure 2 *c* His plate shows plants with a habit more like that of the plants here referred to *C subtilis*, but much larger and more densely branched Some of the plants seen in Nova Scotia also approach this habit

CLAVARIA CRISTATA (Holmsk) Pers — On soil under mixed woods, Upper Brookside, August 8, 1931 (593), Victoria Park, Truro, July 23, 1931 (593a–b) Probably the most abundant of the species of Clavaria Also one of the most variable *C cinerea* and *C rugosa* are regarded by Coker as merely varieties or forms of this species, which is probably the correct interpretation, since all intermediate forms can be found Generally, however, the plants can be easily referred to one or another of these groups, and our collections have been so distributed under these three names

CLAVARIA CINEREA Bull — On soil under mixed woods, Victoria Park, Truro, July 23, 1931 (1131), August 16, 1929 (249), Five Mile River, Hants Co , September 1, 1927 (73), coll A R Prince (6218) The same as *C cristata* but dirty whitish, "light gull gray" to "deep plumbeous" instead of white These plants

dry a grayish or cinereous yellow instead of a clear chamois, as in *C cristata* Very common

Clavaria rugosa Bull — On soil in mixed woods, Upper Brookside, August 14, 1931 (1306), Farltown Road, August 22, 1931 (1306a) This form of *C cristata* is less common than are the other two The clubs are stouter, simple or lobed, irregular, and rugose, and they generally appear deformed Plants of *C cristata* which are parasitized by *Rosellinia Clavariae* (Tul) Rehm (Pl LI, Fig 2) have a similar appearance, and it is possible that plants placed in this species owe their characteristic appearance to a parasitism which is not manifest in any other way The plants dry a yellow ocher

*Clavaria flaccida Fr — On duff under spruce and fir, Salmon River region, August 1, 1931, coll A H Smith (1196), Mt Thom, August 15, 1931 (1196a), Farltown Road, August 21, 1931 (1196b–c) Ochraceous, "chamois" to "light-orange-yellow," 1 5–6 cm tall, with a definite short stem rising from a mycelioid base Branching more or less fasciculate, angles rounded to acute, ultimate tips fine, taper-pointed, lighter in color, often incurved Plants tough-fibrous, flesh white Basidia 4-spored, 7 μ in diameter Spores ellipsoid, brownish, apiculate, minutely spinulose, 6–8 5 × 3–4 μ Base of stem whitish Odor slightly fragrant, taste slightly acrid No greenish stains on plant Coker considers this species a synonym of *C abietina*, but the plants here referred to that species differ in several respects

Clavaria abietina Pers — On duff under spruce and fir, Upper Brookside, August 16, 1931, coll A H Smith (1326) Olive-ochraceous, smaller than *C flaccida*, 1–2 5 cm tall Stem with white mycelial base, branches erect, stout, irregularly fasciculate, tips short-pointed Turning sage-green where bruised, especially toward base Taste slightly bitter Spores ellipsoid-apiculate, brown, finely echinulate when mature, and 7 × 3 μ Drying a greenish to yellow-olive *C flaccida* differs from this species in the usually larger size, ochraceous or tan rather than olive shades (whether fresh or dry), and the lack of any greenish stains

*Clavaria suecica Fr — On decaying leaves or needles under hardwoods or conifers, Earltown Road, August 19, 1931 (1362), August 21, 1931 (1362a), Upper Brookside, September 4, 1931

(1362b), Economy River, August 31, 1927 (54), coll A R Prince (6211) A characteristic species occurring gregariously in troops on leaf mold and duff Plants 2–5 cm tall, pinkish tan to flesh color, pellucid, with a white tomentose base, which continues throughout the substratum as numerous white mycelial strands Flesh tough and elastic Tips short, acute, whitish Base and lower axils with orange-brown scurfy areas Spores ellipsoid, minutely asperulate, hyaline or pale brownish, 7–8 5 × 2 5–4 μ Odor musty or rancid, taste bitter

CLAVARIA GRACILIS Pers — Usually on moss, under conifers, Upper Brookside, August 20, 1931, coll A H Smith (1372), under hardwoods, Earltown Road, August 21, 1931 (1372a), Five Mile River, Hants Co, September 1, 1928 (60), coll A R. Prince (6220) A graceful little species also occurring in troops and arising from a basal system of mycelial strands which mat the leaves or duff together The plants are white to fleshy white, somewhat watery, darker below, fleshy-fibrous, not brittle but pliable, with a primary stem 1 5 cm long and 2–4 mm in diameter, branching in an irregular fashion into a number of slender, erect, often sinuous branches with the tips taper-pointed, often curved Spores ellipsoid, apiculate, hyaline to pale brown, 5–6 × 3–3 5 μ Odor faintly sweetish, taste none or slightly bitter

*CLAVARIA BYSSISEDA Pers — On beech or hardwood leaves, Salmon River region, August 18, 1931, coll A H Smith (1346), Upper Brookside, September 3, 1931 (1346a) This is the third of the tough fleshy-fibrous species found in troops arising from the mycelial strands of a matted substratum Plants up to 5 cm tall, pale pinkish ochraceous ("light ochraceous-salmon"), tips paler ("pale ochraceous-salmon"), base darker Whitish myceloid base soon breaking up in a fasciculate manner into a number of secondary branches, which again divide into fine, erect branches with the ultimate tips long, fine, threadlike, acute, divaricate, or curved Spores ellipsoid, hyaline, apiculate, somewhat "swaybacked," smooth, 10–14 × 2 5–3 5 μ This species is apparently variously interpreted, but our plants fit very well the description given by Coker A reddish color when bruised was seldom noticed, and no greenish tips, which have been reported by some European authors, were seen

The following large, fleshy species of the section Ramaria are the most difficult to place They show a great deal of variation in nature in many of the very characteristics used for specific separation such as color, color changes, stature, taste, and odor There also have been a large number of species based on such characteristics and there is a wide difference of opinion in the interpretation of the older species The writer hopes to have further opportunity to make field observations of these difficult but interesting species in order to determine more accurately the specific limits within the group For the present the collections are referred to those species which they approach most closely, although there is seldom complete agreement with the descriptions

CLAVARIA FLAVA Schaeff *sensu* Coker — Soil under hardwoods, Folleigh Lake, August 29, 1931, coll A H Smith (1429), Upper Brookside, September 5, 1931, coll A H Smith (1429a) Plants 7–20 cm tall, 7–18 cm or more across, "Naples yellow," "antimony yellow," "pale orange" to "ochraceous-orange" Base massive, breaking up into large main branches, 1–3 cm thick, which break up rapidly into a dense, erect, brushlike mass of finer branches, 1–6 mm in diameter Branching irregularly dichotomous, internodes often long and slender, angles acute, rounded, tips short, blunt-pointed, bifid to quadrifid Flesh yellowish or pinkish No stains seen Odor faintly sweetish, taste none Spores ellipsoid-cylindric, apiculate, hyaline becoming pale brownish, smooth (or minutely rough), 9 5–11 × 3 5 μ

This plant fits very well Coker's description of *C flava* Schaeff, although the spores are somewhat larger The *C flava* Fr of Cotton and Wakefield has larger spores (11–14 × 4 5 μ) and shows reddish stains where bruised

*CLAVARIA FLAVA var AUREA Coker — On damp soil under conifers, Folleigh Lake, August 29, 1931 (1428) "Orange-buff" to "mikado orange", where protected, lighter yellow, "amber yellow" to "apricot yellow", base white Plant 5–12 cm tall, base branching into a number of stout main branches, 10–17 mm in diameter, which in turn branch into a number of erect curved, thinner branches with rather long internodes Ultimate tips cusplike, very short, in groups of 3 or 4 Flesh yellow, rather crisp and brittle, fibrous Tips turning reddish vinaceous,

Odor faint, unpleasant, taste none. Spores ellipsoid-oblong, apiculate, hyaline, smooth, 7–8.5 × 3.5 μ. — This plant differs from the collections placed under *C. flava* in the darker orange color, reddish vinaceous tips, and smaller spores. It seems to be closest to Coker's var. *aurea*.

*CLAVARIA OBTUSISSIMA Pk. — On soil under conifers, Earltown Road, August 27, 1931, coll. A. H. Smith (1412); Upper Brookside, August 27, 1931, coll. A. H. Smith (1414); Upper Brookside, August 27, 1931, coll. A. H. Smith (1415). Plants rather large, 9–15 cm. tall, "warm buff" or "amber yellow" to "light ochraceous-buff" or "buff-yellow" when fresh, tips lighter or more yellowish, "baryta yellow" to "apricot yellow." Base white, massive, rooting, 2–5 cm. in diameter, breaking up into a number of stout main branches at the ground line, and rebranching into finer, upright, crowded stems, 1–5 mm. in diameter. Internodes rather long, ultimate tips short, blunt, cusplike. Flesh white, fleshy, fibrous, brittle, or somewhat elastic. Spores ellipsoid-cylindric, apiculate, hyaline to pale brown, smooth, 10–13 × 3–3.5 μ. Odor faintly sweetish. Although very similar in general appearance, color and spores, the three collections differ in minor details and are very difficult to place definitely. They are similar to the plants referred to *C. secunda*, but the spores are longer and narrower. In No. 1415 the tips and bruised places turn a dull cinereous violet or reddish color very slowly and the tips dry a dull reddish. In No. 1412 the vinaceous or reddish stains, where bruised, as in *C. rufescens*, are more marked, but the spores are not striated, as in *C. rufescens*. The main stems of No. 1412 are beset with numerous short, tooth-like branches, as in *C. secunda* (according to Coker), but it does not have the odor or the broad spores of that species. No. 1414 was "amber yellow" to "mustard yellow," with a distinct pinkish caste and concolorous tips, and in this respect it approaches *C. formosa*, but it did not have the yellow tips or the broad rough spores of that species. It is probably the northern pinkish form of *C. obtusissima* mentioned by Coker.

SECUNDA Berk. & Curt. *sensu* Coker. — On soil under conifers or hardwoods, Victoria Park, Truro, July 22, 1931 (1116); Upper Brookside, July 24, 1931, coll. A. H. Smith (1116a); August 20, 1931, coll. A. H. Smith (1371); Folleigh

Lake, August 29, 1931, coll A H Smith (1371a), August 26, 1931 (1371b) These plants are 4–11 cm tall and have the build of *C obtusissima* as given above, but are creamy white to pale tan with tints of pale pink or flesh ("light ochraceous-salmon" to "buff-pink,") rather than with the yellow shades of *C obtusissima* Tips concolorous or lighter or pinkish, often turning reddish brown or cinereous-vinaceous where bruised or aged Odor and taste none or slightly sweetish Spores ellipsoid, apiculate, hyaline or pale brown, shorter and broader than in *C obtusissima*, ochraceous in mass, smooth, 8 5–10 × 4–5 μ (7–8 5 × 3 5–4 5 μ in No 1116) Referred to *C secunda* as described by Coker, although the odor of rancid ham was not noted Coker gives the spores of the type of *C secunda* as 10–12 × 4 5–5 5 μ, but Burt gives them as 10–13 × 3 5 4 5 μ Burt's measurements are again of the type here referred to *C obtusissima* No 1116 is a smaller plant (4–7 cm) with smaller spores and agrees very well with *C verna* Coker except that the growth is decidedly not lax and open but dense and crowded Coker's plate of *C verna* indicates that he may have had only young plants

*CLAVARIA XANTHOSPERMA Pk — On soil, mixed woods, Victoria Park, Truro, July 22, 1931 (1117) Plants 7 9 cm tall, 4–6 cm across, "ivory yellow," "cream color" or "Naples yellow" to "cream-buff," showing dull vinaceous tints where bruised Base stout, stemlike, 1–1 5 cm in diameter, breaking up into stout secondary branches, 6 12 mm in diameter Tertiary branches closely compacted, erect with a broad curving angle, slightly lacunose, irregularly branched, taper-pointed, somewhat brighter yellow Flesh colorless, somewhat watery gelatinous, fibrous-tough Hymenium filled with gelatinous, granular gloeocystidium-like elements which may be young basidia Basidia 8–9 μ in diameter Spores oblong-ellipsoid, flexuous, "sway-backed," bent at one end and apiculate at the other, light yellow brown, 12–14 × 2 5–3 5 μ This species is distinguished by the pale ivory color and the long flexuous spores It is also very close to *C albida* Pk and *C crassipes* Pk

CLAVARIA STRICTA Pers (Pl LII, Fig 2 *b*) — On hardwood logs, New Glasgow Road, July 25, 1931 (1133), Lake O'Law, Inverness Co, Cape Breton Island, August 6, 1931 (1133b), Mt

Thom, August 10, 1931, coll A H Smith (1133c) "Light buff" to "pinkish buff," with vinaceous tints where bruised, tips concolorous, usually with a yellowish or orange bloom in the axils, branching dichotomous Spores oblong-ellipsoid, apiculate, hyaline to pale ocher, 7–8 5 × 3–4 μ

*CLAVARIA ACRIS Pk — On conifer logs, Killag Mines, Halifax Co, July 30, 1931 (1133a, 1179), Salmon River region, August 8, 1931 (1179a) Stems "buff-pink" to "vinaceous-cinnamon," tips somewhat lighter, "light Congo pink" to "vinaceous-pink" Branching more fasciculate than dichotomous, areas of yellowish bloom lighter or absent Spores ellipsoid, apiculate, darker brown than in *C stricta*, 6–7 × 3 5–4 5 μ Taste slightly or tardily acrid, odor slight This species is very similar to *C stricta*, but is found on conifer wood and differs in degree in the characters mentioned above Both these species are quite common

*CLAVARIA PYXIDATA Pers — On decayed logs, Upper Brookside, July 24, 1929 (27), July 10, 1931, coll A H Smith (604) Kauffman (13, p 146) described a species, *C piperata*, as similar to *C pyxidata* but differing in growing on a coniferous substratum, in the presence of cystidia, the subglobose brown spores, and the peppery taste Unfortunately, the substratum of the collections cited above was not recorded There are present, however, long-pointed acicular, hyaline cystidia which project 16–20 μ beyond the hymenium On the other hand, the spores are oblong, 3 3–4 5 × 2–2 5 μ and hyaline, as in *C pyxidata* The peppery taste was slight and developed tardily Further field observations, it is hoped, may serve to clear up the question of the existence of another species.

*PISTILLARIA MICANS (Pers) Fr — On decayed stems of *Cirsium sp*, Salmon River region, July 7, 1933 (1576) Gregarious, clavate, pink, 0 6–1 mm tall, 250–350 μ in diameter, with a short, sterile, white, translucent base Minutely pubescent under a lens on account of the protruding sterigmata and spores. Basidia two-spored, 8–9 μ in diameter, sterigmata 7 μ long, spores hyaline, one-celled, ellipsoid, slightly apiculate, 8 5–10 5 × 5–6 μ No sclerotial base

GYRANS (Batsch) Fr — On fallen leaves, Earltown Road, August 21, 1931 (1776) Plants 8–20 mm. tall, pure white to

dull creamy white, translucent, arising from small, black, subglobose tubers, 0 5–1 mm in diameter Stipe distinct, glabrous, terete, 0 1–0 2 mm in diameter, 5–15 mm long Fertile club thicker, 0 2–0 4 mm in diameter, cylindric-clavate, 2–4 mm long Hymenium about 40 μ thick Trama of large hyaline hyphae, 8–10 μ in diameter Spores elliptic, somewhat flattened or curved, hyaline, 5–5 2 × 2 μ The descriptions in the literature, by Fries and other authors, of this species give the stipe as "pubescent" Batsch (1, Pl 28, Fig 164), however, says "gans mit einem hell-weiszigen Puder bestreut," which may well be His figures also fit our plant perfectly, and if Patouillard's spore measurements of 6 × 2 μ are accurate the species is undoubtedly correctly identified

*Physalacria inflata (Schw) Pk — On decorticated branch, Earltown Road, August 21, 1931 (1384)

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PLATE II

FIG. 1. *Clavaria gracillima* Pk.

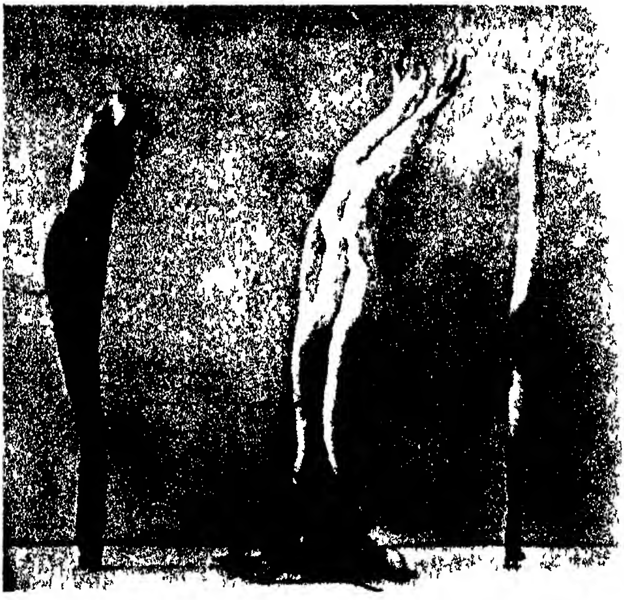

FIG. 2. *Clavaria rugosa* Bull. parasitized by *Rosellinia Clavariae* (Tul.) Rehm

PLATE III

FIG. 1. *Clavaria ligula* Schaeff.

a b c

FIG. 2. a. *Clavaria fusiformis* Sower. b. *Clavaria stricta* Pers., c. *Clavaria Kunzei* Fr.

CARPEL ANATOMY OF THE BEAN (*PHASEOLUS VULGARIS* L.)

EDWARD F. WOODCOCK

A VERY complete study of the vascular anatomy and morphology of the vegetative portion of the bean plant has been made by Doutt (2), but very little concerning the detailed structure of the mature fruit has been published. Nelson (5), in his studies of bean mosaic, briefly described the general arrangement of the vascular tissues of the bean fruit.

The earlier researches on the fruit of the Leguminoseae had to do with the embryology. Schleiden and Vogel (7) described floral development and endosperm formation in more than fifty species of this group. Tulasne (8) described the embryo of *Lathyrus Aphaca*, and Hoffmeister (4), that of a number of Leguminoseae. Hegelmaier (3) reported on the embryology and endosperm development of Lupinus. Saxton (6) studied the development of the embryo sac and embryo of *Cassia tomentosa*. Weinstein (9) made a careful study of the cytology of the gametophytes, fertilization, embryo, and endosperm development of *Phaseolus vulgaris*. Brown (1) reported on the development of the embryo sac and embryo in five varieties of *Phaseolus vulgaris*.

METHODS AND OBSERVATIONS

The anatomy of the fruit was observed by making cross and longitudinal sections with the microtome and staining them with contrast stains. Free-hand sections were also used in making some of the interpretations.

The bean fruit is a dehiscent, monocarpellary, unilocular structure having one parietal placenta and several seeds attached along the placental region. In the young flower at about the time of fertilization the carpel is a flattened structure, which becomes hollowed out as development proceeds. The ventral suture, which bears the ovules, has arisen in the process of evolution by the union of the margins of

the sporophyll The dorsal suture corresponds to the midrib of the sporophyll The inner tissues of the pod, next to the locule, correspond to the spongy region of a dorsiventral leaf, and the outer tissues, to the palisade

By carefully splitting a pod apart along the ventral suture and along the median line of the dorsal suture it is observed that the alternate ovules are attached to opposite halves of the carpel, as Nelson has shown (Pl VI *E*) This suggested to Nelson and Doutt that there might be two distinct vascular bundles in the ventral suture region of the pod Their observations showed this to be true, but no detailed study of the vascular tissue was carried out

These two bundles correspond to the two main lateral veins of the leaf Since alternate ovules in the carpel are attached to each of these two bundles, half of the ovules have a different vascular supply from the other half Thus in a carpel containing six ovules, ovules one, three, and five have a vascular connection with one bundle while ovules two, four, and six are connected to the adjacent, parallel bundle The ovules have no direct vascular connection with the single large dorsal bundle of the carpel

The outer epidermis of the carpel wall consists of cells nearly isodiametric in transverse section (Pl LIV, Figs 1, 3) A study of a section through the stoma (Fig 1) shows that the cell adjacent to the guard cell is pushed out to such an extent that the large substomatal air space is almost completely cut off from the stomatal aperture This large air space is connected with other smaller air spaces between the small, somewhat rounded cells of the adjacent tissue Directly below the epidermal cells is a few-celled layer whose cell walls are slightly thickened and in which there are no intercellular spaces The tissue region below the loosely arranged parenchyma of the carpel wall (Fig 3) is formed by elongated polyhedron-shaped cells, the long axis of which is at right angles to the long axis of the carpel In this region appear the vascular bundles which have arisen almost entirely as branches from the large dorsal bundle A few cells below this region, toward the locule, are numerous small, nearly isodiametric, parenchyma cells, among which there are no intercellular spaces The remaining portion of the carpel wall is made up of larger, close-fitting, polyhedral parenchyma cells There is no well-developed epidermis next to the locule The writer has made no study of the tissue changes which occur in the carpel wall as ripening occurs.

A careful study was made of the course of the vascular bundles in the carpel wall and in the ovule Doutt (2) states that the traces to the pistil consist of the portions of the bundles of the central stele, which do not pass out as traces to the bracts and to the three other whorls of floral parts These divide and form a more or less continuous circle of twelve bundles in the stele Six of these bundles move toward the posterior or ventral suture and six toward the anterior or dorsal suture The writer finds that, after leaving the base of the pistil, only two of the twelve bundles form the ventral suture bundles (Pl LIII, Fig 1) The other ten bundles form an anastomosing system (Fig 2) which constitutes most of the vascular supply for the rest of the carpel wall The dorsal region of the carpel is supplied by a union of two of the ten bundles This large compound bundle extends the length of the carpel and gives off branches to the carpel wall The two ventral bundles only occasionally give off branches which connect with the rest of the vascular system of the carpel

The vascular supply to each of the several ovules is of much interest A series of cross-sections through the carpel from the base to the apex shows that each of the two vascular bundles of the ventral region (Fig 3) is composed of two rather distinct regions The larger outer region is composed of three or four radiating rows of thick-walled tracheary elements These rows are separated by parenchyma cells and are associated, toward the outside of the carpel, with small, thin-walled phloem cells The smaller region is nearer the center of the carpel and is separated from the larger region by several parenchyma cells This region is also adjacent to the ventral suture area and shows very little if any anastomosing with the larger part It is from this smaller part of each of the two ventral bundles that the vascular supply is formed to the ovules The alternate ovules in a carpel are thus each supplied from this small bundle In the region of the funiculus there occur much anastomosing and twisting of the vascular elements (Pl LIII, Fig 5)

The funiculus of the ovule is somewhat S-shaped (Pl LIV, Fig 2), since the point of origin is at one side of the median line of the ventral region of the carpel The distorted vascular elements become normal in shape and position as the vascular strand leaves the funiculus (Pl LIII, Fig. 4) The xylem portion of this bundle is toward the stylar end of the carpel

The course of the vascular tissue through the funiculus and into

the chalaza and integument region is diagrammatically shown in Plate LIV, Figures 4 and 7 Soon after the bundle passes through the hilum region of the ovule (Fig 4) it bends toward the chalazal region and divides into three bundles (Fig 7) The central bundle continues to the chalaza, where it makes an abrupt turn to reach the base of the nucellus and integuments The other two branches form a horseshoe-like structure, with the open end near the microphyle and with the long axis of each nearly parallel with the long axis of the carpel (Fig 6) There are sent off from these branches others which anastomose to form the vascular supply of the integuments (Figs 5, 7)

SUMMARY

The unilocular monocarpellary fruit of the bean is supplied by a vascular system which arises as twelve bundles at the base of the carpel These become arranged in such a way that there are two large ventral bundles and one large compound dorsal bundle with the intervening region of the carpel supplied largely by the anastomosing of the other eight bundles and by branches from the dorsal bundle The smaller independent portion of each ventral bundle gives off a branch to each alternate ovule, since half of the ovules are attached to the region corresponding to the margin of the sporophyll and the other half are attached to the other margin Soon after the vascular bundle enters the ovule it becomes divided into three portions The central part goes to the chalaza, and each of the other two divisions goes into the integuments along the side of the nucellus and sends off anastomosing branches

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EXPLANATION OF PLATES LIII–LIV

*Carpel of **Phaseolus vulgaris** L*

Abbreviations A, area shown in Plate LIV, Figure 3, B, plane of section for Plate LIII, Figure 1, CB, carpel wall bundle, CH, chalaza, DB, dorsal bundle, E, epidermis, EM, embryo, F, funiculus, G, guard cell, H, opening in hilum, I, integuments, IE, inner epidermis, LP, large part of ventral bundle, M, micropyle, O, ovule, P, phloem, PB, primary bundles of integuments, PL, plane of section for Plate LIII, Figure 2, S, small part of ventral bundle, SB, secondary bundles of integuments, T, thick-walled cells, V, vascular bundle of funiculus, VB, ventral bundles, X, xylem

PLATE LIII

Fig 1 Cross-section of carpel just above base Section cut through plane indicated by broken line *B* in Figure 2 × 16

Fig 2 Longitudinal section through base of carpel Plane of section indicated by broken line in Figure 1 × 16

Fig 3 Cross-section of ventral bundles of carpel × 80

Fig 4 Cross-section of funiculus bundle as it passes through hilum region of ovule Xylem portion is toward micropyle × 320

Fig 5 Cross-section of funiculus bundle as it enters the funiculus, showing the distorted vascular elements × 207

PLATE LIV

Fig 1 Cross-section through stoma and substomatal region × 207

Fig 2 Diagram of cross-section of carpel through ovule

Fig 3 Detail of carpel wall Area indicated by *A* in Figure 2 × 75

Fig 4 Longitudinal section of carpel wall and ovule × 12

Fig 5 Longitudinal section of ovule cut to show the secondary bundles, which arise from the two large lateral primary bundles of the ovule × 16

Fig 6 Longitudinal section of ovule cut along axis of the two large lateral bundles × 16

Fig 7 Diagram to show arrangement of vascular bundles in ovule

PLATE LIII

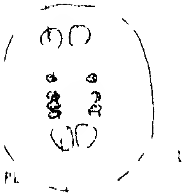

Fig 1

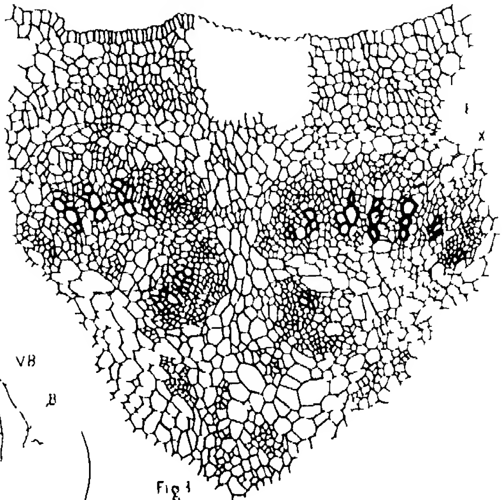

Fig 3

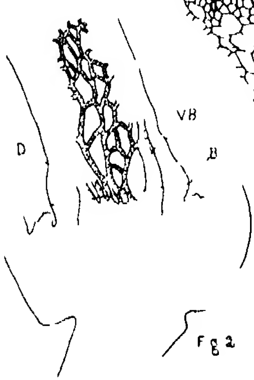

Fig 2

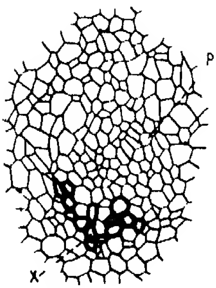

Fig 4

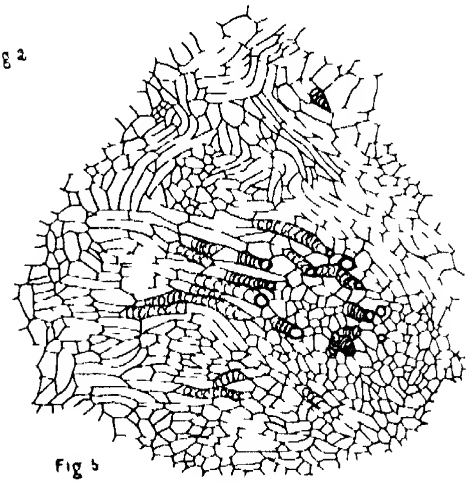

Fig 5

Anatomy of *Phaseolus vulgaris* L

PLATE LIV

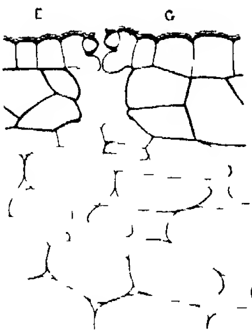

Fig 1

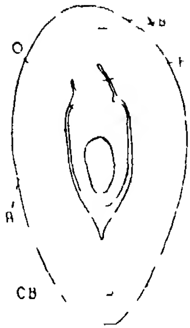

Fig 2

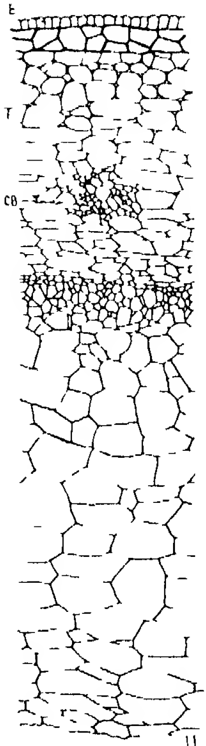

Fig 3

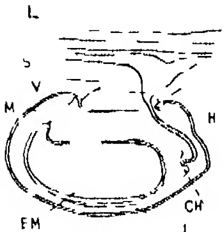

Fig 4

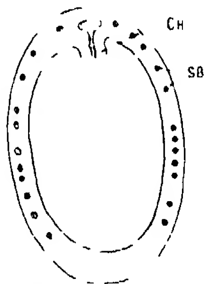

Fig 5

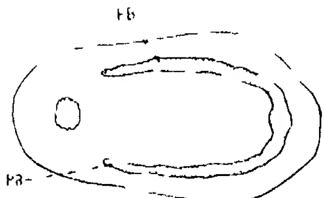

Fig 6

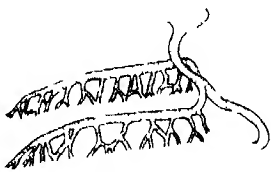

Fig 7

Anatomy of *Phaseolus vulgaris* L.

SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES VI

DOW V BAXTER

KNOWLEDGE of the North American resupinate polypores began with the early collections of Ravenel, Curtis, Ellis, Schweinitz, and Peck During the period of their work this knowledge found expression chiefly in short diagnoses of the species Since that time so many other plants have been described and so many variations of former species discovered that it is now generally recognized that the species are particularly difficult to identify

The studies reported thus far in this series of investigations have been concerned largely with keys to different species and descriptions of some of them In paper V (1) the growth characteristics of several resupinate polypores were presented, together with a discussion of their morphological characteristics Descriptions of ten species were recorded there The present paper is a continuation of the work reported in the earlier publications of this series These studies are primarily concerned with *Poria subacida* Pk ,[1] its distribution, its hosts and substrata, and its action upon white cedar wood Eight hundred and ten one-year decay-resistance tests for white cedar, *Thuja occidentalis*, are reported

Poria subacida (Pk) Sacc
Syll Fung , 6 325 1888

Polyporus subacida **Peck Ann Rep New York State Mus , 38 92 1885**

(See also Pls I, III, IV of Vol VI, *facing* p 76, and Pl XXXVII of Vol XIV, *facing* p 290)

Fructification annual or perennial, effused for 2 meters or more, separable to inseparable, up to 10 mm thick, margin subiculose,

[1] I am indebted to many individuals for specimens and for the privilege of examining collections found in various herbaria Acknowledgment is due to the authorities of the New York State Museum, the New York Botanical Gar-

tomentose, sterile at first, becoming fertile with age, "ivory yellow" [2] to "pinkish buff", subiculum conspicuous, 0 3 to 1 mm thick, concolorous with margin, tubes 0 5 to 9 mm long, mostly 4 mm or less, sometimes stratified in 2 or 3 layers, mouths white or straw-colored when fresh, then "cinnamon-buff," "pinkish cinnamon" to "Verona brown," or "warm sepia," circular to angular, fringed, 2-6 to a mm in the typical eastern plant, usually 2 3, and in the western form 4 5 to a mm (both forms present in the West), basidia hyaline, 10–12 × 7-8 μ, 4-spored, spores hyaline 1-2-guttulate, mostly 1, broadly ellipsoid or oblong ellipsoidal, 2 5-5 (3 5 × 5) 4–6 μ, large crystalline bodies often present in the trama, tramal hyphae without cross walls or clamp connections, 1 5 μ, mostly 3 μ in diameter, cystidia absent, or to be seen as small sterile organs projecting beyond the hymenium

Four varieties of *P subacida* have been recognized by Peck Var *tenuis* is very thin, with short tubes mostly 0 5 mm long, but up to 2 5 mm The surface is nearly even This variety occurs on the smooth decorticated trunks of hemlock Var *tuberculosus* is characterized by a more or less roughened surface caused by the scattered or clustered presence of unequal prominent tubercles Overholts (4) has called attention to the fact that they appear to be a monstrous development of the mycelium on the surface of the pores Var *stalactiticus* also has a very uneven surface, caused by its incrusting the moss-covered logs It exhibits unequal porous protuberances It often occurs on fallen mossy trunks of birches Var *vesiculosus* (*P vesiculosus*) B & C is another shallow-tubed form (4) In this plant pores average 3 to a mm *P ornata* (Peck) Sacc is distinguished from the other plants of this series by the presence of a spotted margin Drops of water which occupied these areas have evaporated from them

den, the Missouri Botanical Garden, the Division of Pathological Collections in Washington, Division of Forest Pathology, the Field Museum of Natural History, the University of Wisconsin Herbarium, and the University of California Herbarium I am under special obligation to Dr L O Overholts, who has given abundant help during this entire period of study Thanks are also due to Dr Clara W Fritz and Dr Irene Mounce for the attention given to white cedar material sent to them for examination

[2] Colors given in quotation marks are those of R Ridgway, *Color Standards and Color Nomenclature* (1912)

Allied species — It has been indicated in the description that there is considerable range of variation in this plant, particularly in the pore size of certain western forms and those observed in eastern collections The range of thickness — some plants up to 1 cm — is large, and this feature often gives entirely different aspects to the very thin and the thick watery types Some of these forms are closely allied to *Poria medulla-panis* (Pers) Cooke The smaller and much-branched hyphae of *P medulla-panis* serve to separate it from *P subacida* The fructification of *P medulla-panis* tends to be more corky

Specimens of *P crassa* Karst [3] are also very likely to be confused with the forms which are closely allied to *P medulla-panis* *P crassa* varies from snow-white to lemon-yellow and does not exhibit the distinct subiculum which is present in typical collections of *P subacida* It is usually white to straw-colored, then "cinnamon-buff," and is not lemon-yellow *P crassa* specimens, too, generally become chalky in texture, while typical specimens of *P subacida* remain crisper The spore characters of the two plants should also be compared

Cultures — Isolated from *Thuja plicata*, Vancouver, British Columbia, and from decayed wood of *Thuja occidentalis*, Atlanta, Michigan The mats of mycelium on the malt agar remain snow-white for the first two weeks of growth Later the fungus turns slightly yellow In one-year-old white cedar block cultures the mycelium is "cream color" to "cinnamon-buff "

P subacida belongs to the "rapid-growth" class and also to that group termed the "large-range" class [4] Differences in growth rates between the cultures obtained from the two sources are minor ones, as shown in Table I Since light has practically no effect upon the rate of growth, *P subacida* falls in the same class as *P ferrea* and *P inermis* with respect to this reaction

Habitat — *Abies balsamea, A grandis, A lasiocarpa, Acer saccharum, A rubrum, Alnus sp , Betula alba* var *papyrifera, B lenta, B lutea, Castanea dentata, Fraxinus nigra, Juglans cinerea, Juniperus vir-*

[3] Name used for thick form of *P xantha*

[4] All porias which fill petri dishes in fourteen days at the temperature of their optimum growth are placed in the "rapid-growth" class Those plants exhibiting a growth of 5 mm or more at fourteen days over a range of more than 21° are said to have a large temperature range and belong to the "large range" class

TABLE I

RATE OF GROWTH EXPRESSED IN MM OF *PORIA SUBACIDA* PK FROM *THUJA PLICATA* AND THE FUNGUS CAUSING THE LAMINATED ROT IN *THUJA OCCI* REFERRED TO *P SUBACIDA*

Period in days	5°		10		15		20°		25°		30°	
	From white cedar	From red cedar	From white cedar	From red cedar	From white cedar	From red cedar	From white cedar	From red cedar	From white cedar	From red cedar	From white cedar	From red cedar
7	0/6*	0/5	1 0/6	1 6/5	14 0/6	19 2/5	22 5/6	24 2/5	33 3/6	36 8/5	35 1/6	38 0/5
14	0/6	0/5	17 3/6	14 8/5	30 0/6	30 4/5	40 0/6	40 0/5	40 0/6	40 0/5	40 0/6	40 0/5
21	0/6	0/5	30 6/6	30 8/5	40 0/6	32 0/5	40 0/6	40 0/5	40 0/6	40 0/5	40 0/6	40 0/5
28	3/6	0/5	34 3/6	40 0/8	40 0/6	38 4/5	40 0/6	40 0/5	40 0/6	40 0/5	40 0/6	40 0/5

* Number of tests

giniana, Larix laricina, L occidentalis, Liquidambar styraciflua, Picea canadensis, P engelmannii, P mariana, P sitchensis, Pinus contorta, P divaricata, P echinata, P monticola, P ponderosa, P resinosa, P rigida, P strobus, P virginiana, Platanus occidentalis, Prunus sp, Pseudotsuga taxifolia, Quercus alba, Q borealis var *maxima, Thuja occidentalis* (?), *T plicata, Tilia americana, Tsuga canadensis, T heterophylla*

Distribution — British Columbia, Labrador, Newfoundland, Nova Scotia, Ontario, Quebec, Yukon Territory, Alabama, Alaska, Arkansas, California, Colorado, Florida, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, Washington, West Virginia, Wisconsin.

Occurrence — Common, especially in coniferous forests

Decay — A spongy rot In the early stages of attack numerous black spots ordinarily appear in the wood These become surrounded by a whitened area, and the black spot later disappears

The whitened areas enlarge, and the wood around the spots becomes straw-colored There is a tendency for the annual rings in some woods to separate The white cavities become more numerous and coalesce, finally rendering the heartwood a soft spongy mass of water-soaked fibers and mycelium Ordinarily it is possible to compress water from such a mass of white fibers The so-called feather rot [5] in balsam is likewise usually confined to the roots and lower end of the first log The rot begins as minute cavities, causing the annual rings to separate from each other Black spots occur in the affected wood After a time the tree may become hollow, and the surrounding wood is reduced to a mass of water-soaked fibers This mass of badly decayed wood has a feathery appearance, which accounts for the name given to the decay

Von Schrenk (5) states that "the mycelium of the fungus spreads through the individual tracheids after entering the tree and collects in spots here and there Solution of the wood cells begins around these centers which at this time appear dark brown or black They are the dark spots referred to above Heartwood and sapwood of the spruce are destroyed with equal rapidity All parts become spongy, with the exception of the resinous basal pieces of the branches, which resist the attack of the fungus even after the whole trunk has been destroyed"

Importance — Although *P subacida* is reported here on thirty-nine different woods (for an example see Pl LV), actual estimates of the damage caused or of any "beneficial effects" to the forest from the deterioration of slash are not available In a detailed survey of the slash-inhabiting fungi found on Michigan swamp species after logging in Montmorency County *P subacida* represented a very small percentage of the total number of fungi observed This survey was made over a period of several years and at different seasons Fruiting bodies seldom occurred on the slash on this particular area, but when found this fungus was

[5] Indications are that the common feather rot of balsam is caused by *P subacida* McCallum (3) says "The identity of the causal fungus of this type [feather rot] of decay has not been proven by scientific methods, but the indications are that it is *P subacida* Pk *Only in a few cases was a fungus noted* in connection with this rot, and then in fallen trees In these instances it was always *P subacida* Cultural work with this decay and with red rot has yielded no positive results as far as the production of fruiting bodies is concerned"

most frequently on tamarack and spruce General observations, however, indicated that it was associated with the decay of balsam known as "feather rot" Data gathered by Weir (6) in his studies of the effect of broadcast burning on the growth of cull-producing fungi in Idaho and Montana show *P subacida* to be one of the most important fungi on spruce and white pine

Aside from the part that the fungus plays in the destruction of slash, serious losses are known to be sustained in standing timber as a result of its activities The rot itself, however, rarely extends throughout the full length of the tree, it is usually confined to the butt sections McCallum (3) points out that "The average extent of the rot up the trunk is from six to ten feet Because the rot is ordinarily confined to the basal portions of the tree it is not the loss from decay of wood that makes this rot an important one of our northern swamps, but rather its capacity to act as a contributory cause to windthrow of the affected trees On a representative area of 2¾ acres there were 37 balsam firs which had first been weakened by feather rot and then broken off by wind At this rate, in a square mile of similar forest there would be 9,970 such trees, or about seven per cent of the total stand of this species"

Although *P subacida* occurs on balsam, spruce, tamarack, and other trees in the swamp and muskeg areas in the region of the Great Lakes, fruiting bodies of it have never been observed in association with decayed white cedar Several special intensive surveys have been made for it on this wood in the region and, in addition, interested observers detailed on other timber, land, and economic surveys have not seen it fruiting on *T occidentalis* The abundance of rot in this species on certain areas, however, led to a special study of this important decay

Poria subacida and the decay of white cedar — The heartwood of standing white cedar is frequently rendered so worthless by decay that in certain areas of the swamps of the Great Lakes the timber is left standing by the loggers (Pl LVI, Fig 1) Much of the decay is the common "brown cubical" rot, which has been attributed to *Polyporus balsameus* (Pls LVII, LVIII, Fig 1)

Another rot which is prevalent elsewhere and which is equally frequent in certain areas of this region is the common stringy-laminated type (Pl LVIII, Fig 2) Numerous isolations made

from wood decayed by this type result in cultures of a heart-rotting fungus which is not *Pol balsameus*

Several hundred subcultures made from this second fungus have been kept under different environmental conditions (Pl LIX, Fig 1) There have also been attempts to compare and "match" them with other cultures of known origin No fruiting structures have appeared in any of the cultures

Since the general appearance of the fungus resembles that of *Fomes pinicola*, cultures were obtained from fruiting bodies of this plant on *Populus balsamifera* (Pl LX) *F pinicola* occurs commonly on this tree on the so-called hemlock knolls in the northern swamp areas, where the field work for this study was conducted For the purpose of matching it seemed, therefore, very desirable to obtain cultures not only of this fungus but also of those from the area where the decay of the balm of Gilead was associated with that of the white cedar

So many differences were discovered later in the actual growth characteristics of the two fungi that that from white cedar cannot be considered to be *F pinicola* In addition to differences in the character of the mycelial growth of the two plants, the types of rot caused by the two organisms are distinct *F pinicola* is not known to occur on *Thuja occidentalis* and in general is rare on any of the cedars I have found it, however, in Alaska on *Chamaecyparis nootkatensis* on Baranoff Island (one collection) and at Ketchikan (one collection)

Although the rot caused by *P subacida* in several conifers is very similar to the laminated decay type discussed here, and although the general appearance of cultures of *P subacida* and of the fungus from white cedar is also similar, the identity of the causal fungus of this decay in *T occidentalis* has not been demonstrated Circumstantial evidence, however, points to the fact that it is probably *P subacida*

P subacida, unlike many other fungi, commonly fruits on *Thuja plicata*[8] (Pl LVI, Fig 2) Collections of this fungus on the western red cedar from British Columbia have been made The growth of the cultures obtained from these specimens is compared with that of fungus found on white cedar, *T occidentalis*, in Table I

[8] Fruiting bodies of any species of the genus Fomes are not common on the cedars

TABLE II

One-Year Tests of Resistance of White Cedar to Decay

No of rings to inch	No. of blocks inoculated	Average specific gravity	Average oven-dry weight grams	Water absorbed average grams	Average weight water absorbed in blocks grams	Average weight upon removal grams	Moisture content upon removal average grams	Average mycelial cover	Average oven-dry weight tested blocks grams	Average loss in weight	
										Grams	Percentage
2–4	6	0.38	20.93	36.19	57.12	28.00	8.08	0.45	19.92	1.02	4.87
4–6	118	0.33	21.46	33.24	54.70	37.28	17.03	0.45	20.24	1.21	5.64
6–8	70	0.36	23.07	33.16	56.23	39.26	17.06	0.4	22.20	0.87	3.77
8–10	70	0.37	24.81	35.25	59.92	43.09	19.29	0.5	23.80	1.01	4.07
10–12	93	0.40	25.76	33.96	59.74	43.20	18.75	0.55	24.46	1.30	5.02
12–14	37	0.41	26.50	35.01	61.50	45.87	20.36	0.5	25.51	0.99	3.74
14–16	17	0.41	22.02	28.98	50.99	32.12	11.16	0.6	20.96	1.07	4.86
16–18	16	0.38	26.02	31.12	57.08	35.63	10.86	0.5	24.78	1.18	4.11
18–20	18	0.40	25.10	29.22	54.32	37.77	13.53	0.5	24.23	0.87	3.47
20–22	11	0.38	23.42	30.74	54.16	40.21	16.96	0.3	23.25	0.17	0.73
22–24	15	0.38	23.64	30.20	53.85	35.31	12.08	0.3	23.24	0.40	1.70
24–26	23	0.38	24.29	32.80	57.07	39.84	15.94	0.1	24.30	0.38	1.56
26–28	30	0.38	24.95	36.90	61.85	41.66	16.97	0.3	24.64	0.29	1.16
28–30	25	0.38	24.80	35.65	60.46	40.52	15.26	0.2	24.44	0.15	0.60
30–32	29	0.38	24.91	36.08	60.98	39.06	14.27	0.1	24.80	0.11	0.44
32–34	41	0.39	25.33	35.71	61.04	36.40	12.63	0.1	24.88	0.45	1.78
34–36	24	0.40	25.47	31.77	57.24	37.78	13.11	0.2	24.68	0.80	3.14
36–38	21	0.40	25.55	32.97	58.52	37.88	14.02	0.3	24.34	1.21	4.74
38–40	24	0.43	27.46	32.29	59.75	41.51	15.35	0.25	26.16	1.30	4.73
40–42	39	0.43	27.11	30.16	57.26	39.59	13.24	0.3	26.35	0.76	2.80
42–44	14	0.44	28.40	31.15	59.56	48.71	22.23	0.7	25.84	1.80	6.16
44–46	17	0.42	27.77	32.35	60.16	38.68	11.36	0.3	27.31	0.43	1.55
46–48	18	0.44	28.14	31.31	59.45	43.66	16.15	0.23	27.53	0.61	2.17
48–50	11	0.45	28.69	32.70	61.28	51.36	23.89	0.47	27.57	1.12	3.82
50–52	6	0.44	27.25	31.26	58.51	41.57	15.25	0.2	26.32	0.93	3.41
52–54	7	0.44	29.07	29.61	58.68	45.37	18.41	0.4	28.39	0.89	3.06
54–56	3	0.41	27.32	30.89	58.21	38.77	12.17	0.1	26.60	0.72	2.63
56–58	4	0.47	29.85	32.84	62.69	33.80	6.68	0.6	27.13	2.72	9.11
58–60	2	0.51	33.50	32.65	66.15	45.70	14.15	0.45	31.55	1.95	5.82
66–68	1	0.47	30.70	37.42	68.12	44.40	14.60	0.1	29.80	0.90	2.93
Total	810		783.29	983.60	1766.72	1204.00	450.84		755.22	27.69	
Average		0.41	26.11	32.79	58.89	40.13	15.03	0.4	25.17	0.91	3.54

P.E. = ± 0.263

One-year tests on the resistance of white cedar to decay have been made in the same manner, in general, as that described by Hubert (2) The blocks used were 4 inches by 1 by 1 They were put in wide-mouthed Erhlenmeyer flasks containing the inoculum which had been allowed to grow over the surface of the malt agar at the bottom of the containers They were placed on sterile glass slides which rested on the mycelium In Table II it can be seen, then, that the average loss in weight for the 810 blocks after one year in culture was 0 91, or 3 54 per cent of the oven-dry weight

The loss in weight varies from 0 1 gram in the twenty-nine blocks tested which belong to the 30–32-inch class to 2 7 grams for four blocks in the 56–58-ring class The P E = ± 0 263 The ring classes 56–68 have been omitted since few blocks are represented, and the results the tests made deviate greatly from the arithmetical mean

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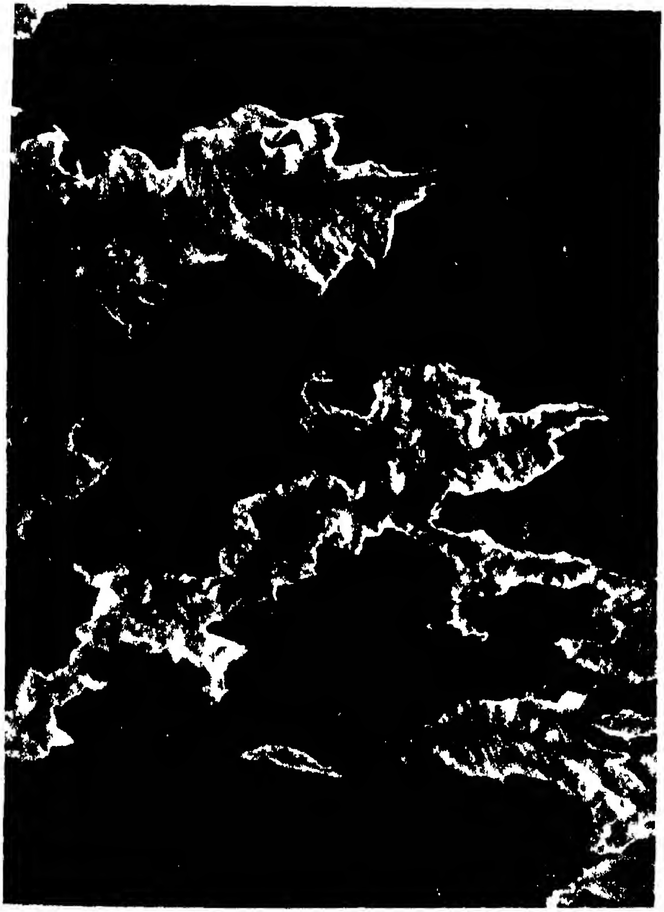
PLATES LV–LX

PLATE IX



Poria subacida on *Tsuga heterophylla*

PLATE LVI

FIG. 1

FIG. 2

FIG. 1. Wet rot or laminated decay caused by *P. ... ...* in white cedar ... ... left by loggers because of this defect. Atlanta, Michigan.

FIG. 2. *F... ... abietis ... Thuja ... ...* Vancouver, British Columbia, 1932.

PLATE LVI

body of *Polyporus balsameus* at branch base of white
Grand Island, Michigan

PLATE LVIII

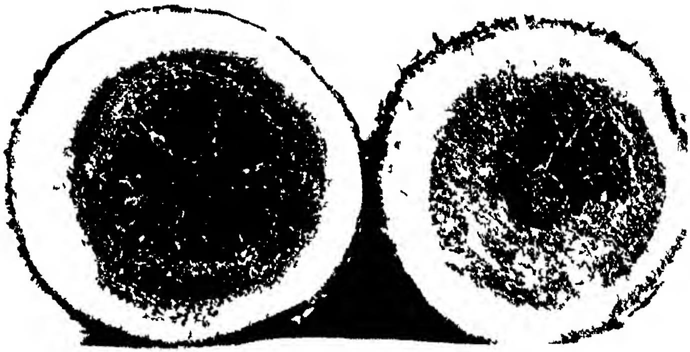


Fig. 1. Cubical rot of white cedar. This decay is caused by *balsameus*. Atlanta, Michigan.

Fig. 2. Laminated type of rot from which cultures were obtained. This type of rot is probably caused by *Poria subacida*.

PLATE LIX

Fig. 1.—*Poria subacida* (?) from *Thuja occidentalis* cultured on white cedar sapwood (left) and white cedar heartwood. The fungus grows rapidly on white cedar.

Fig. 2.—Decay resistance test of white cedar blocks from tree obtained in the so-called featherbed swamp type, Atlanta, Michigan (culture nine months old).

PLATE IX

FIG. 1. *Fomes pinicola* from *Populus balsamifera*, Atlanta, Michigan. Cultured on malt agar in the dark (left) and in the light (culture two weeks old).

FIG. 2. *Poria subacida* from *Thuja plicata*, Vancouver, British Columbia, on malt agar in the dark (left) and in the light (culture two weeks old).

FIG. 3. *Poria subacida* (?) from *Thuja occidentalis*, Atlanta, Michigan. Cultured on malt agar in the dark (left) and in the light (culture two weeks old).

FORCE EXERTED BY WOOD WHEN MOISTURE IS ABSORBED I

A METHOD OF MEASUREMENT

WILLIAM KYNOCH

THE ability of wood to absorb or to give up moisture in response to variations in the moisture conditions of the surrounding medium and to swell or to shrink in consequence is one of its most outstanding and familiar characteristics Though this property can occasionally be turned to advantage, as in tightening the seams of boats or the joints in wood-stave water tanks or pipe lines, it is, in general, a serious handicap to the usefulness of timber as an industrial material In the use of wood for building construction, furniture, flooring, interior finish, doors, window sashes, and many other purposes, annoyance and expense frequently result from the changes in dimensions and shape induced by gain or loss of moisture

It is true that the difficulties referred to can be partly obviated by application of scientific information and data yielded by timber research For example, it has been shown that wood exposed to any constant conditions of relative humidity and temperature will come to an equilibrium with these conditions That is, it will assume a definite moisture content The time required to reach equilibrium depends chiefly upon the species of wood and the dimensions of the individual pieces (8) [1] Wood in any given use is exposed to varying conditions of relative humidity and temperature, but such variation naturally occurs within a certain range only Hence the wood varies in moisture content between certain reasonably definite limits The shrinkage and swelling of wood may, for most practical purposes, be regarded as directly proportional to change in moisture content below the fiber saturation point, when the moisture is evenly distributed If, therefore, the material is conditioned, to the proper

[1] Numbers in parentheses refer to literature cited, pages 289-290

moisture mean between the limits referred to, immediately prior to being put into use, it will undergo the least possible amount of shrinkage and swelling in service Investigation has established such mean figures for a considerable variety of uses of wood (4)

It has been shown, also, that the degree to which wood will shrink or swell as its moisture content changes depends largely upon its specific gravity (9), increasing (with certain exceptions) with rise in the specific gravity figure Selection of as light a wood as will give satisfactory service in the particular use, tends therefore, to minimize difficulties due to "working"

Again, heating wood to high temperatures, by means of steam or otherwise, somewhat reduces its tendency to respond to external changes in moisture conditions by altering in size (5), and advantage can sometimes be taken of this fact However, when all the scientific and technical knowledge of wood at present available has been brought to bear upon practical shrinkage and swelling problems we are still far short of their complete solution

Valuable contributions to knowledge of the phenomena of shrinkage and swelling have been made by a number of investigators It was established by Tiemann (12) that when green wood is dried true shrinkage does not begin until a certain critical point (the fiber saturation point) is reached Brown (1) showed the existence of a silicious framework, in the cellular elements of wood, of a structure such that it offers a relatively high degree of resistance to longitudinal shrinkage of the cell wall, while opposing lateral shrinkage in a relatively slight degree Roth (11) and Clarke (2) reported the observation that the inner walls of the thick-walled elements of heavy woods possess a higher shrinkage potential than do those of the thinner-walled fibers of lighter woods, thus accounting for the greater over-all lateral shrinkage of heavy woods Ritter (10) has demonstrated the existence, in the cell wall, of minute, spirally disposed strands (fibrils) the orientation of which with reference to the main axis of the cell favors lateral, as against longitudinal, shrinkage or swelling Koehler (6) has reported the result of research on the longitudinal shrinkage of wood He has shown that the angle made by the fibrils with the main axis of the cellular elements in the spring wood of a number of woods is greater than that occurring in the cells of the summer wood (7) If, as he suggests, water in the cell wall is held between the fibrils and not within them and if, as seems certain, the fibrils recede

from or advance toward each other with intake or outgo of cell-wall water, the cause of the greater longitudinal shrinkage of spring wood, in drying, as compared with summer wood, observed in various timbers, clearly appears A similar difference with regard to the angle of the fibrils, between wood of normal weight and abnormally light wood within the species, may explain the greater longitudinal shrinkage of the latter found to take place in tupelo, cypress, and other woods

Knowledge of the general anatomical structure of wood indicates some of the reasons for the excess of tangential, over radial, shrinkage or swelling In this connection it is pointed out by Forsaith (3) that increase in the width of the summer wood, tending to augment radial shrinkage, makes for a reduction in the disparity between the shrinkage in the tangential and that in the radial direction

The general subject of the shrinkage and swelling of wood is of such practical moment to the timber-fabricating industries that every phase of it demands thorough investigation Several phases have as yet received but scant attention, and among these is that of the force exerted by wood when it absorbs moisture

It has long been known, in a general way, that this force may be of considerable magnitude In ancient practice in quarrying stone use was made of this knowledge by drilling a line of holes in the rock, driving in dry wooden pegs and then soaking them with water The force exerted by expansion of the wood was sufficient to fracture the rock along the desired line (7) Wood swelling under confined conditions of this character is capable of exerting a force great enough to crush the cells, to accomplish this, pressures varying from some 300 to some 1,500 pounds per square inch are necessary (8) However, definite figures on the force developed by common woods in different directions with respect to the grain, when moisture is absorbed under stated conditions, are entirely lacking With a view to obtaining such figures an experimental study has been begun at the University of Michigan

A problem which presented itself at the outset was that of devising means by which measurement of the forces in question could be made After trials of various types of equipment which might serve the purpose, it was decided to work out accessory apparatus which could be employed in conjunction with an ordinary standard universal testing machine The equipment and procedure described

below were therefore developed and after careful test were accepted for use in the study

A Riehlé Universal testing machine of 50,000 pounds capacity was made available for the work A metal pan is placed on the weighing table of the machine A pin affixed to the under side of the bottom of the pan, and inserted into a small hole in the weighing table, allows the pan to be placed in the desired position Water, to a depth of about half an inch, is run into the pan, which is lined with cloth to facilitate evaporation

A modified ball-and-socket, brass bearing block (Pl LXI), forming the support for the test specimen, is placed in the pan A small recess in the under side of the base, when engaged with a projection attached to the bottom of the pan, centralizes this support Four small projections on the upper side of this fitting serve to locate the test piece in the proper position thereon The lateral and vertical orifices observable in the fitting permit entry of moist air, which thus obtains access to the basal portion of the test piece and makes its way into the body of the specimen by way of small vertical holes traversing the specimen lengthwise and lined up with those in the block To obtain a proper bearing of the test piece upon the block at all points of contact the vertical holes in the block are of smaller diameter than those in the wood specimen Care is taken to keep the water level low enough to prevent the liquid coming into contact with the test specimen

A circular brass bearing block (Pl LXI) is placed on the top of the test specimen Its concave upper portion is machined to receive the hemispherical end of a vertical steel shaft (Pl LXI) This part of the assembly thus forms a second ball-and-socket connection These blocks compensate for any small deviation from parallelism between the upper and lower surfaces of the test piece and insure a uniform distribution of stress The steel shaft constitutes the lower portion of an attachment fitted into the recess in the movable head of the testing machine

After the test piece has been placed in position between the bearing blocks the shaft is lowered into its socket, and a slight pressure (just sufficient to hold the whole in true perpendicular alignment) is applied A closely fitting rubber cover, provided with a hole through which the shaft passes, is placed over the pan Thus the test piece is inclosed in a humidity chamber such that the moisture content of the specimen (initially low) increases relatively rapidly

As the specimen absorbs moisture it swells and exerts a pressure on the weighing table of the machine, the magnitude of which can be determined by adjusting the scalebeam poise and taking readings in the usual manner

Since, however, this would involve constant attendance upon the machine, day and night, it is obviously necessary to have some automatic means both of adjusting the poise (as often as this is required) and of recording the readings This is accomplished as follows A small electric motor, actuated from the lighting circuit, is mounted on the frame of the machine (Pl LXII) This motor drives a pulley (Pl LXII) carried by a small shaft from which, in turn, the power is transmitted to a larger pulley attached to the hand-wheel operating the poise

Two small bronze contact pieces are attached one to the frame of the testing machine and the other to the large end of the scale-beam assembly (Pl LXIII) Each is insulated from the machine These pieces are connected with the motor and are so placed that when the scalebeam is in balance with the load (i e is horizontal) they are out of contact When the load increases and the scalebeam rises, contact is made, the motor is actuated, and the poise is moved forward until the beam is again balanced

Automatic recording of the pressures developed by the expanding test pieces under the conditions of the investigation is secured as explained below

The upper part of the housing of the scalebeam figure dial is removed and replaced by a metal support which carries a circular disk of exactly the same diameter as the dial (Pl LXII) The edge of the disk rests upon the edge of the dial When the dial moves through any fraction of a revolution the disk is rotated through an equal distance The weight of the disk is sufficient to provide the necessary friction to prevent slippage at the low peripheral speeds obtaining

A circular chart graduated in the same manner as the dial is affixed to the disk and a pen (carried by a bronze arm attached to the disk support and set at zero at the beginning of a test) records on the chart travel of the dial and thus registers the magnitude of the force exerted by the test specimen as it absorbs moisture from the humidity chamber

The test piece (Pl LXI) is cylindrical, nominally 3 inches high and

1 658 inches in diameter when at a moisture content of approximately 5 per cent (based on oven-dry weight) It is completely traversed lengthwise by thirteen equidistant holes, each one eighth of an inch in diameter The cross-sectional area (not including that of the holes) is thus nominally two square inches and the volume nominally six cubic inches The test piece was designed with the object of keeping the moisture gradient low at all stages, that is, of maintaining as uniform a moisture distribution throughout the specimen as possible

The test pieces are so cut that each direction of grain (longitudinal, radial, and tangential) is represented by a separate set of pieces Longitudinal specimens have their long dimension parallel to the grain, radial specimens parallel to the rays, tangential specimens, at a tangent to the growth rings Specimens are made in pairs, each being accompanied by a second made from material which grew end to end, or side by side, with it in the same tree One member of each pair is used for the actual test as previously described The other, employed for determination of moisture content, is placed in the humidity chamber close to its companion and between similar bearing blocks, when the test begins Each is weighed immediately before a test The check piece is withdrawn, weighed, and replaced at intervals during the progress of a test The force recorded on the chart is noted each time At the conclusion the oven-dry weight of each piece is determined The moisture content of the test and check pieces at the beginning and end of the test is computed as, also, is that of the check piece at each of the intervals mentioned above

The assumption is made that the moisture content of the check piece will closely approximate that of the piece actually under test at any stage in the testing process The close agreement found between the initial and final moisture contents of matched pairs is held to justify this assumption

The length and the diameter of each wood specimen are measured to an accuracy of 0 01 inch at the beginning of a test and its volume is computed

All blanks for the making of test pieces are cut from strictly sound, clear, straight-grained heartwood taken from timber of commercial size They are dried under control to a moisture content closely approximating 5 per cent (based on oven-dry weight) Blanks are then turned and drilled under conditions corresponding as nearly as

possible to an equilibrium moisture content of 5 per cent The finished test pieces are then stored under the original controlled moisture conditions and are withdrawn, a pair at a time, as required for testing For preliminary tests a minimum of ten matched pairs of specimens in each of the three directions of the grain is employed From every log or piece of timber from which test piece blanks are sawn at least three extra blanks are cut These are used for determination of specific gravity, the method followed is that specified in "Standard Methods of Testing Small, Clear Specimens of Timber" (Serial Designation, D 143 — 27, American Society for Testing Materials)

Testing is carried out at room temperature with an approximate mean of 70° F The pressure exerted, under the conditions of the study, increases until the test specimen attains a certain moisture content and then decreases as the moisture content continues to rise The pressures developed are correlated with moisture content and are expressed as pounds per cubic inch

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PLATE LXI

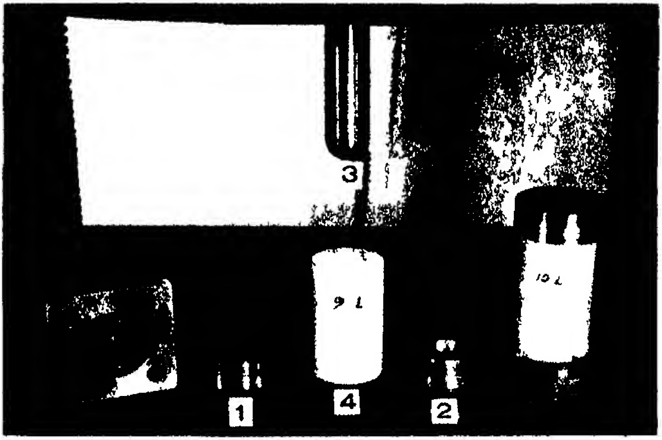


FIG. 1.—(1) Lower bearing block for test specimen; (2) upper bearing block for test specimen; (3) steel shaft with hemispherical end; (4) cylindrical specimen.

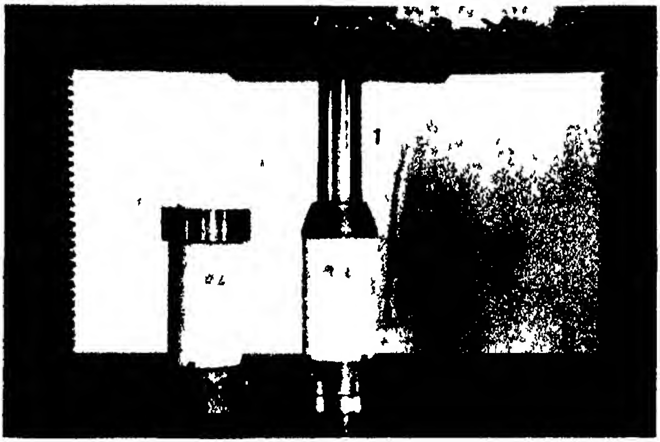
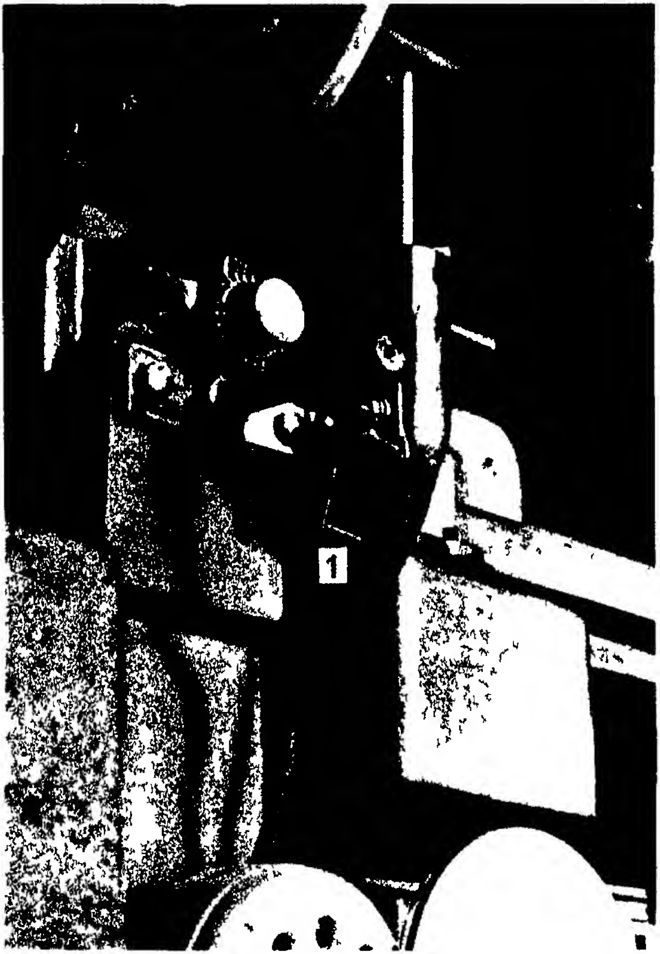


FIG. 2.—(1) Steel shaft in concave recess in top of upper bearing block.

Figures showing force exerted by wood when moisture is absorbed.

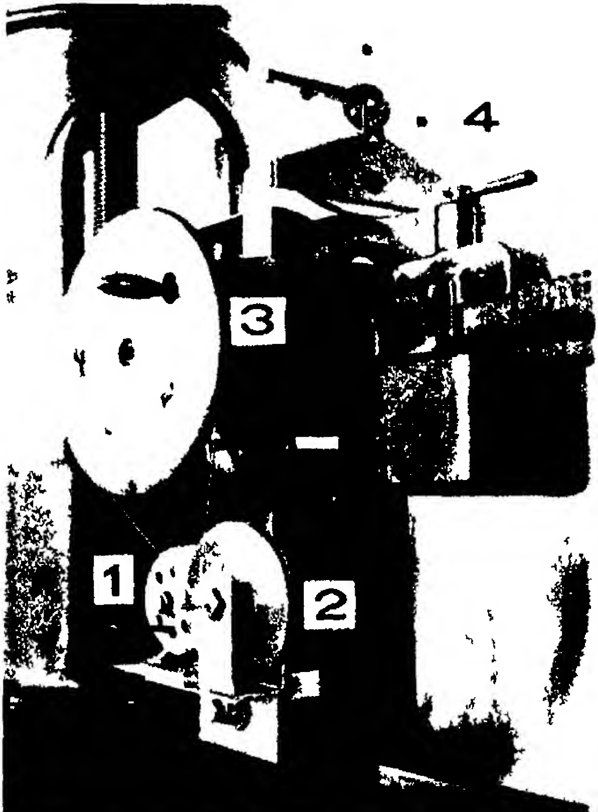
PLATE LXII



Force exerted by wood when moisture is absorbed

(1) Bronze contact pieces which close the electric circuit and thus start the motor when the scalebeam rises slightly above the horizontal position

PLATE LXIII



Force exerted by wood when moisture is absorbed (1) Electric motor (2) small pulley driven by motor (3) large pulley which is attached to the wheel operating the scalebeam poise and to which power is transmitted from the shaft of the small pulley (4) disk carrying the recording chart with its support and pen arm shown

SILVICULTURAL OPERATIONS IN RED PINE PLANTATIONS, WITH PARTICULAR REFERENCE TO THE HURON NATIONAL FOREST

LOUIS POMMERENING

FORESTERS have always recognized the fact that cultural operations must play an important part in forest development in the Lake States region Thousands of acres will be planted in the near future, which, together with the vast areas already planted, will need cultural treatment if the investment is to pay dividends It is therefore essential and timely that we summarize our knowledge and experience in cultivating young stands in order that the desired product may be obtained in the shortest possible rotation Reforestation and fire protection are important phases of forestry, but cultural work, although less obvious, is becoming increasingly important

On the Huron National Forest, which makes up a large part of the lower Au Sable River drainage basin in the northeastern portion of the Lower Peninsula of Michigan, there are approximately 45,000 acres of red pine (*Pinus resinosa* [1]) plantations ranging in age from a few years to twenty Here silvicultural work must of necessity find a definite place Prior to 1933 none of consequence had been done to improve the existing conditions Fortunately, President Roosevelt's unemployment relief program made it possible to get this work under way, and to date (March, 1934) over 4,500 acres have had treatment

The deep sandy soil on the plains area of the Forest makes red pine especially adaptable for planting, since this species develops strong lateral roots and a substantial taproot when young All stock is planted six feet apart in furrows at approximately eight-foot intervals. Generally a 20 to 50 per cent cover of jack pine (*Pinus banksiana*) and scrub oak exists at the time of planting Most of the site is poor, owing perhaps to the repeated burning over in years past,

[1] Also known as "Norway pine"

which left very little ground cover and decomposed litter necessary for soil improvement. Except where it grows as a thicket, the jack pine in the plantations is of the low branchy type and has very little value. The oak overstory is in most places a young stand reproduced by sprouting and is commonly diseased by fungi. Except as fuel the oak has very little utilization value. Silviculturally, however, the oak improves the soil through leaf decomposition and also protects the underplanting from the hot, dry, summer winds. Most of the plantations carry from 300 to 1,500 trees to the acre, including all species. On some sites mortality has been extremely high, leaving as few as 250 red pines to the acre. Some of the causes for high mortality may be dry weather, excessive shade, poor stock, poor planting, or some destructive agency, such as injury by rabbits or insect infestation.

From the standpoint of growth and survival both jack pine and oak develop much better than do the more valuable species. They offer strong competition to the planted stock and because of their aggressiveness easily suppress the red pine to such an extent that recovery is impossible after ten or twelve years. Consequently, cultural treatment of the planted areas is absolutely necessary. Liberation cuttings and cleanings are the most important phases of this type of work. The operations eliminate the jack pine wolf trees, which, because of their widespreading crowns, excessive shade, and spruce-bud worm infestation, seriously affect the height growth of the red pine. Also they remove those jack pine and oak trees which are of comparatively the same height and age, but which are growing too close for the best development of the planted trees. Liberation cuttings and cleanings thus improve the composition of the plantation by the proper spacing of the less valuable species with respect to those which are more desirable. Only those trees which have no silvicultural value whatsoever in the stand are removed. An attempt is made to improve the site and at the same time to allow the red pine to grow without a hindrance of any kind. Sometimes this involves merely the pruning of several branches which have a tendency to whip the top branches and leaders of the most valuable species.

Often small, scattered, even-aged stands of jack pine alone form the overstory, and here the problem of cultural treatment requires keen judgment to determine whether the jack pine is sufficiently thrifty to warrant its retention in the stand or whether the suppressed

red pine is still more valuable to justify a heavy release from the jack pine In many instances of this kind, when the red pine shows evidence of not having been suppressed too long, a 50 per cent release is effected This should result in giving the intolerant planted stock an even chance to come through and compete favorably with the jack pine for a place in the stand

In practically all plantations there are, of course, many standing dead trees which have no value whatsoever These are removed for the good of the stand, first, because of the damage which might occur in case of windfall and, secondly, because they increase the fire hazard

In addition to the cultural measures involving release and sanitation cuttings one of the most perplexing problems arose concerning the method of disposing of the enormous amount of slash created from such cuttings It appeared serious because of the age and density of the red pine and because of the fire hazard Various methods were discussed at length, both in the field and in the office, and it was finally concluded that during the summer months, when the fire hazard was high and when disposal by burning would be exceptionally dangerous, coniferous slash would be windrowed in piles three and one-half feet high between furrows This facilitates handling for future burning when snow falls Deciduous brush is lopped to within twelve inches of the ground and is scattered uniformly

Even when snow was on the ground, it was feared that burning the slash would result in many scorched trees if the fires were made too large On the other hand, it would be too costly to start numerous small fires or possibly to carry the brush long distances to the few larger openings Something inexpensive had to be devised in order to burn on a large scale and economically Several thin sheet-metal shields five by six feet, with a frame of scrap lumber, were constructed to protect the more valuable species where fires were built in the small openings The shields were placed on the windward side of the fire and from about eighteen inches to two feet in front of the planted stock, so that an air space would result and save the tree from the intense heat This provided ample protection and permitted a good-sized fire in the small openings Several fires to an acre could easily be built to shorten the distance the slash had to be carried A large number of these shields were constructed at a cost

of about ninety cents each, and brush-burning was instituted on a large scale

In conducting the cultural operations it was found that a twelve-man crew under a "strawboss" functioned most effectively The strawboss was first trained in the technique of the work by the forester in charge, and when put in command of a crew he was furnished with written instructions covering all important points Their purpose was to make the accomplishments of the respective crews as uniform and as consistent as possible However, occasional actual participation in the project and daily personal supervision by the forester is essential, so that the strawboss may know from the outset exactly what will be required of him

In order to facilitate organization and to prevent poor work a strip method is used for covering each forty-acre tract The crew moves across the "forty" in a strip two chains wide At each five-chain interval stakes are set up, establishing the corners of a one-acre area The entire crew is then kept concentrated within this one-acre segment and can be given close supervision This method also makes it possible to check each individual's work Among other advantages it allows the strawboss to keep a systematic record of the number of stems of various sizes which are cut, the number of valuable species remaining, the areas in need of planting, and the exact location of the work at all times

All trees to be cut are marked by the strawboss and the forester When the men have become proficient this is no longer necessary

With men who are more or less familiar with the axe and saw it has been possible to maintain an average production of approximately 0 35 of an acre per man per day, over a period of five months This includes actual release, brush disposal, and decking of all fuel and pulpwood which are salvaged from the material cut On the basis of 2,516 acres released and 7,330 man days the cost was approximately $11 00 per acre About two fifths of this amount may be charged to brush disposal The figures given apply only to work performed by NIRA labor However, on areas where ECW labor was used and also a lower wage scale, the cost of release amounted to approximately $9 70 per acre

Despite the fact that these costs may seem at first to be excessive, it must be remembered that each crew in its stand-improvement work

is carrying on three different operations, all of which are absolutely necessary in the practice of intensive forestry

There is every indication that even the considerable costs involved in maintaining continuously favorable growing conditions in the red pine plantations are a sound financial investment It is particularly fortunate that emergency conservation measures have made possible such large-scale application of silvicultural measures Whether or not the work is continued, the large areas treated will be invaluable in the future study of silvicultural technique and of the economics of management of red pine plantations

United States Forest Service
East Tawas, Michigan

THE URBAN GEOGRAPHY OF SAGINAW, MICHIGAN

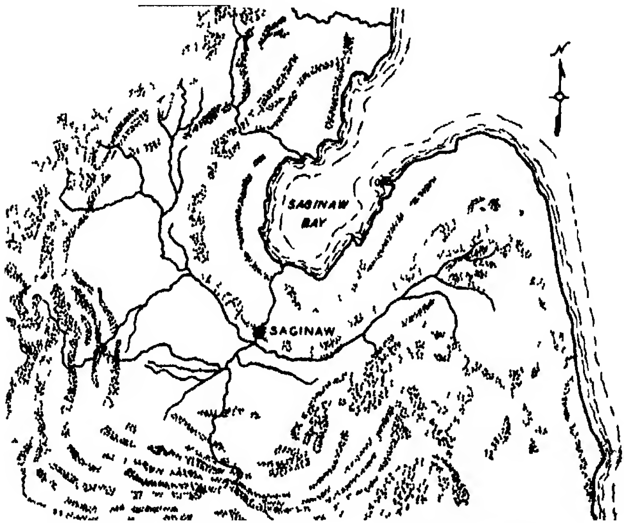
DENNIS G. COOPER AND FLOYD A. STILGENBAUER

THE City of Saginaw grew up on the best site for the dispensation of materials and services in the resourceful Saginaw Basin. Early speculation in real estate led to the development of two rival settlements nearly opposite each other along the Saginaw River. The strong competition which sprang up between them increased with the rise of forest extraction and the development of transportation routes, and resulted not only in a rivalry that has existed in mild form even to the present, but also in an urban landscape pattern with off-center semicircles of growth such as are found in but few cities of the United States. Consolidation of these two cities finally became economically necessary in order to meet the pressing problems of a declining lumber business and to make commercial and industrial readjustments. Within recent years diversified industries have replaced lumber mills, but the factories and the transportation facilities of the present reflect the influence of the past forest activities and the more recent agricultural and mineral developments in the valley.

Saginaw is located about one hundred miles north of Detroit, twenty miles upstream from Saginaw Bay, at a focal point in the Saginaw Basin, which is for the most part a broad lowland with a gently undulating surface dipping imperceptibly toward Saginaw Bay. Since the basin was formerly covered by glacial lake waters, its soil is composed chiefly of lake-bed clays and clay loams which, when well drained, are of high fertility. Although the region is close to the northern limit of profitable agriculture, the rainfall and temperature conditions permit the growth of a wide variety of crops, and the Saginaw Lowland is now a region of great agricultural productivity. Underlying it are rich deposits of salt and considerable coal and oil. Originally the basin was covered with forests of both hard and soft woods, and especially with the magnificent white pine,

which grew in the higher, sandier parts of the basin It was almost inevitable that a good-sized city would grow up in a region so wealthy in natural resources

The Saginaw Basin is drained by an irregular system of streams and rivers characteristic of glacial drainage The upper tributaries



MORAINIC BELTS AND DRAINAGE PATTERN OF THE SAGINAW LOWLAND
SCALE

MAP 1

of the system empty into four leading waterways the Cass, Flint, Shiawassee, and Tittabawassee rivers These streams in turn converge, forming the Saginaw River, which flows northward for twenty-two miles to Saginaw Bay (Map 1) The actual site of Saginaw was in large part determined by this focus of major streams, for it was the custom in the early days for the Indians to establish

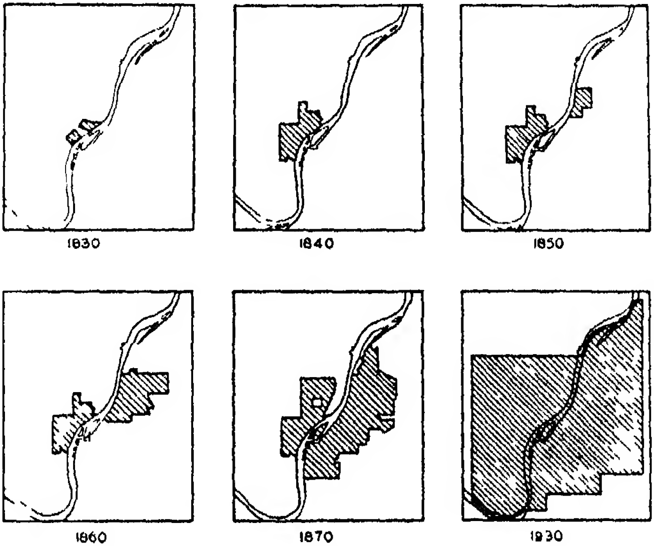
camps at the mouths of the larger rivers, at confluences of several streams, or at points of convergence of trails following such streams The land surrounding the confluence of these major streams was low and marshy, unsuitable for permanent human habitation or for all-year-round land trails However, not far to the north of this area there crossed the basin in a northwest-southeast direction a low but fairly wide water-laid moraine, along the top of which ran one of the principal Indian trails of the region The Saginaw River, flowing through a gap in this formation, swung to the west at this point and cut into the moraine, forming a bluff along the river for some distance Back from the bluff, between the Saginaw River and the Tittabawassee River to the west, the land was high and level and well above the reach of flood waters Owing to the height of the land and its location with respect to land trails and water routes, this site was used from time immemorial as a camping ground by the Indians The southwest trend of Saginaw Bay and the low, wet lands of the lower Saginaw Valley further influenced the extension of trails toward this favorable crossing point

Fur traders entered the Saginaw region late in the eighteenth century, for traffic with the Indians they naturally chose locations near camping grounds or at points of vantage along principal trails [1] Thus it was that on the west bank of the river, and close to the Indian camp grounds, a trading post was established in 1816, around which a small colony of white settlers soon gathered Mainly through the efforts of Lewis Cass the United States Government acquired a large portion of the Lower Peninsula of Michigan by the Treaty of Saginaw in 1819, when the Saginaw country passed from the hands of the Indians forever Shortly after, the United States War Department sent a detachment of soldiers to the Saginaw River, not only to protect the fur trade, but also to encourage further settlement and agriculture Tents were pitched on the Indian camp grounds, and a strong stockade was later erected In 1822 and 1823 lands just to the north of the military reservation were platted and offered for sale One of these plats was called the "Town of Sagana" (Map 2)

Movement of Easterners into the Saginaw region was early stimulated by the first public land sale in the United States and by

[1] Fuller, G N, *Economic and Social Beginnings in Michigan* (Wynkoop Hallenbeck, Crawford Company, Lansing, Michigan, 1916), p 375

the beginning of navigation on the Great Lakes in 1818, it was further encouraged by the opening of the Erie Canal in 1825 New York financiers recognized the importance of the position of Saginaw and decided to promote the building of another town on the east side of



AREAL GROWTH OF SAGINAW

1830–1930

MAP 2

the river The land directly across from the town was not chosen as the site for the new city, since a marshy island extended for a considerable distance along the bank (Pl LXIV) Consequently a spot some distance north of Saginaw, on the east side of the river, was selected, to be known as East Saginaw Here a new town, born on a levee that was flanked by a marshy flood plain, but nour-

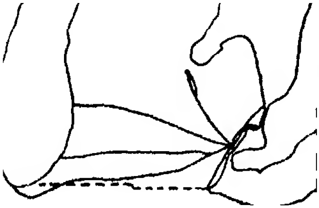
ished by an abundance of brains, capital, and perseverance, quickly became a thriving community

The superior quality of the white pine which grew in many parts of the Saginaw Basin was early recognized, and logging crews were soon cutting into this immense stand of virgin timber Saginaw was favored by its location to become the center of the lumbering activities which were springing up in all parts of the valley The rivers and tributaries affluent to the Saginaw River gave access to an area of 3,200 square miles of some of the finest timber in the country Down these waterways the logs were floated to Saginaw, which occupied the strategic position just below the point where the waters from the many rivers flowed together Mills for converting the logs into lumber were built along the river at or close to the city The lumber was at first consumed locally, but by 1847 shipment to the East was begun The value of this lumber quickly attracted attention in the Lower Lakes region and in the East, and an immediate demand for it was made upon the Saginaw mills

At about this time salt was discovered on a farm to the south of Saginaw, where the town of Salina subsequently sprang up This settlement soon became a part of East Saginaw, owing to the rapid expansion of the larger city At about this time salt deposits were discovered in other parts of the valley The presence of brine under the Saginaw region had been known for some time, but it was not until 1860 that the first successful salt well was completed and the manufacture of salt begun The industry did not make much headway at first, since the cost of fuel necessary for the evaporation of salt was so high as to be prohibitive Then it was found that the exhaust steam from the engines in the sawmills could be used to evaporate salt from vats and pans, which resulted in such a saving that manufacture was undertaken on a large scale In this way the lumber and the salt industries were definitely combined

Though the growth of the lumber and the salt industries was the main factor in bringing about the general development of the Saginaws, transportation routes caused the more rapid rise of East Saginaw The first road leading out of the Saginaw Valley was made in 1821 by the soldiers stationed at Saginaw It was cut through the woods, following an ancient Indian trail, and over it supplies from Detroit were hauled to the soldiers For many years this road was

the only connection between Saginaw and the outside world (Map 3) In 1841 a national military turnpike between Saginaw and Detroit was completed over the same route Several years later the state



Map 3 Stage lines in Michigan in 1835 (drawn from A E. Parkins, *Historical Geography of Detroit*, p 261)

constructed a plank road from East Saginaw to Flint, a distance of thirty-two miles This new road, built by the capital and through the enterprise of the founders of East Saginaw, did not border the

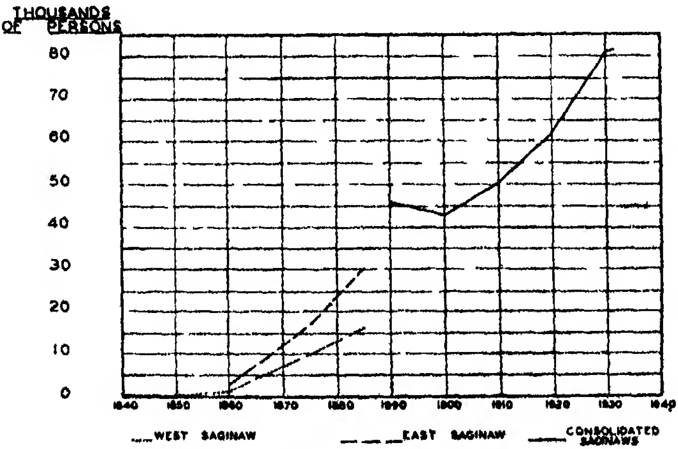
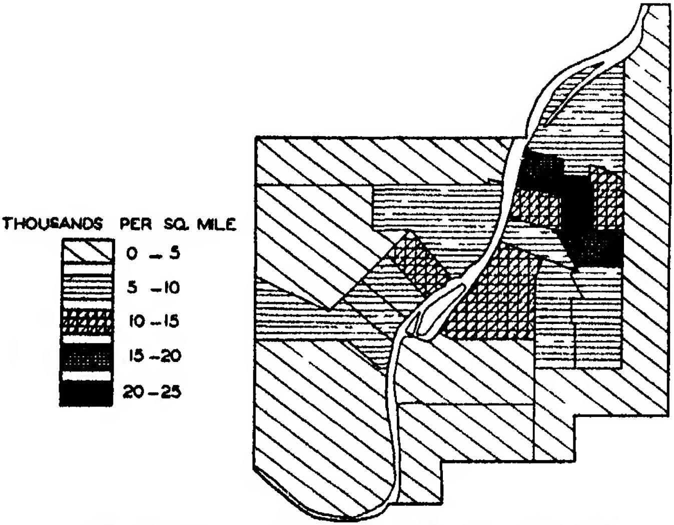


Fig 4 Population of Saginaw, Michigan, 1840–1932

river, as the earlier roads had done, but entered East Saginaw from the southeast, carrying traffic from Flint directly to the new city Consequently East Saginaw, located on the Detroit-Flint side of the river, grew rapidly, whereas Saginaw City, being off the main line of

travel and on the opposite side of the river, was in a disadvantageous position and suffered accordingly (Pl LXV, Fig 1, text Fig 4, Map 4)

At an early date it was realized that railroads were essential to the proper development of the region In 1857 the Pere Marquette Railway was organized, and plans were made to lay a line from Saginaw to Flint Since the project was financed principally by busi-



MAP 4 Distribution of the population of Saginaw by wards, 1930

ness men of East Saginaw, the line was laid to enter East Saginaw to the north of the business section This put Saginaw City at a further disadvantage (Pl LXV, Fig 1) In 1864 the line was completed all the way to Detroit, the connection put Saginaw in direct communication with the East, South, and West From this time on, economic progress in the valley was rapid, with East Saginaw as the industrial center The lumber industry provided so much tonnage for the early railroads that the Grand Trunk and Michigan Central railways laid lines to Saginaw, and soon a network of tracks reached into many parts of the city

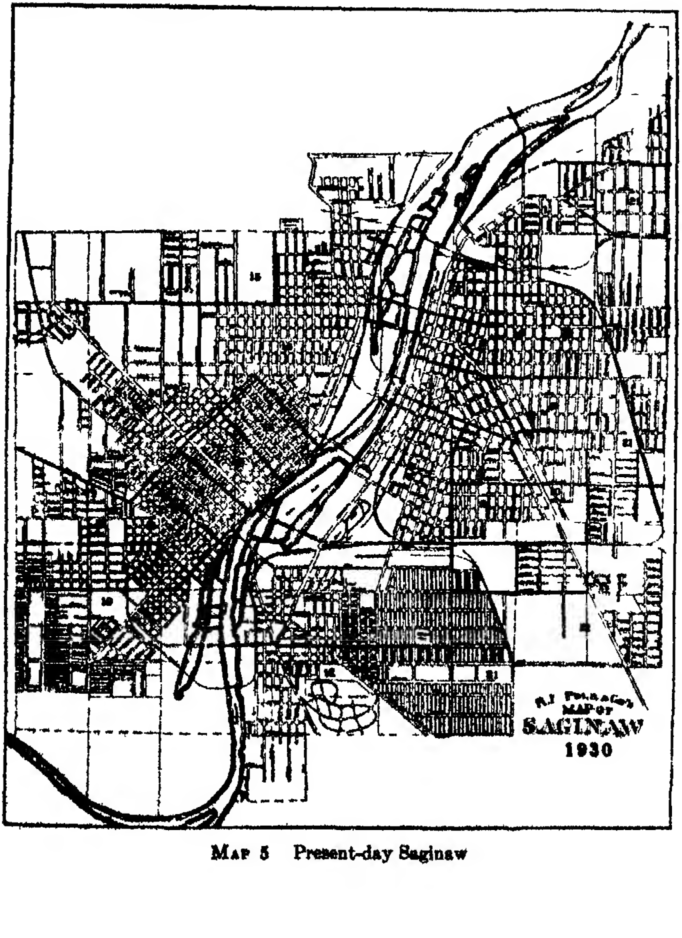
Lumber production dominated the life of the city until 1882, the peak year of the industry at Saginaw In that year over a billion board feet of lumber were logged on the Saginaw River But the great pine forests could not last forever, and by the next year lumber production had declined considerably With the slowing down of the sawmills, salt production could not be carried on economically, and consequently it also fell off The decline in the lumber and the salt industries became seriously felt late in the 'eighties, and with the resulting rapid decrease in population it was realized that other industries were needed if Saginaw was to remain a prosperous city Finally, in spite of the strong rivalry existing between East Saginaw and West Saginaw, the progressive leaders of both sides decided that consolidation was essential to their progress, and accordingly in 1889 the two cities united to form the City of Saginaw In this way the necessity for separate governments was done away with, and communication and trade, which had always existed to a considerable extent, were furthered In spite of this union a feeling of petty jealousy has endured even to the present, but it is generally treated with mild humor or with indifference

Up until about 1885 the large valuable tracts of hardwood tributary to the valley had hardly been touched, but factories for the utilization of this timber finally began to appear[3] Then, in an effort to encourage industrial development, the Saginaw Improvement Association in 1890 purchased a large amount of low, inexpensive land on both sides of the river in the southern part of Saginaw, where they offered free factory sites for prospective industries Several large factories responded to the offer and located in Saginaw The evolution from the cutting of pine trees and the making of lumber and salt to varied industries of a more permanent nature is still going on During the transition period the natural resources of the valley have been developed, and a large number of industries established by manufacturers from outside, aided and encouraged by the capital which was once employed in the lumber and salt business.

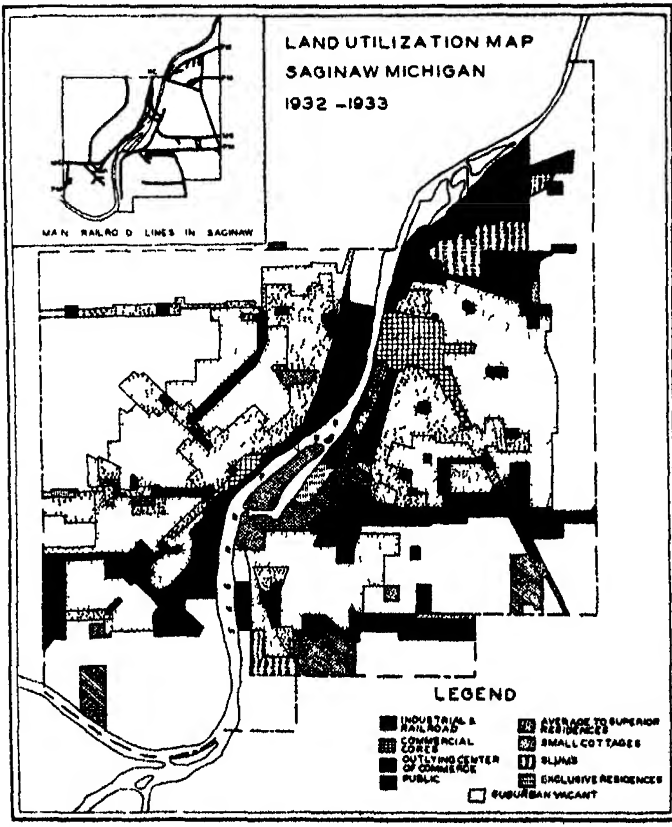
The nature of the industries of Saginaw is indicated by the following table

[3] Mills, J C, *History of Saginaw County, Michigan* (Saginaw, Seeman and Peters, 1918), I 489

Number of plants	*Products*	*Number of employees*
6	Automobile parts	7,500
14	Machinery and tools	2,500
15	Furniture and woodworking	1,500
8	Foundry and machine shops	1,500
16	Food products	1,200
76	Diversified	1,800
135		16,000



Map 5 Present-day Saginaw



MAP 6 A comparison of the land utilization map with the railroad map (inset) brings out the close relationship between railroads and industrial areas in Saginaw

Saginaw is now essentially a manufacturing city, and it will probably remain so Owing to the flatness of the land on both sides of the river, railroads are not confined to the valley, but come in from all directions Railroad transportation is therefore excellent, as are facilities for navigation Besides this, an ample supply of fuel

mined in the vicinity and a recently completed pure water system having a filter capacity of twenty-five million gallons daily enough to supply the needs of residents and manufacturers alike — have also played a part in making Saginaw one of the principal industrial centers of southern Michigan

Saginaw has retained its position as an industrial and a commercial center largely because of the many railways and highways connecting it with central Michigan The railroads, laid down during the boom years of the lumber industry, come from a hinterland which not only contains a number of thriving towns and cities but is also for the most part a highly productive agricultural district Saginaw is the center of the Michigan bean and sugar industry, it has the largest bean elevator in the world, which annually handles eighty million pounds of beans It is the distributing center of the valley, there are in the city at present more than forty wholesale houses, which cover a radial territory of over a hundred and twenty-five miles

Saginaw today has an area of seventeen square miles, approximately nine of which are developed (Map 5) Although outward growth has been quite regular, the landscape pattern is a complicated one, owing to the fact that the modern city is really made up of two earlier cities located on opposite sides of a river, but not directly across from each other Instead of circles of growth which characterize cities of normal development, we find semicircular patterns set apart which, if placed opposite each other, would resemble the normal city The land in Saginaw is employed approximately as follows (see Map 6)

Use of land		*Percentage of total political area*
1 Vacant		40
2 Residential		24
a Small cottages	15 0	
b Middle class to superior	7 0	
c Slums	1 5	
d Exclusive	5	
3 Streets		20
4 Industrial and railroad		9
5 Public and semipublic property		4
6 Commercial		3

The main commercial areas of Saginaw are situated at and about major foci of local and regional transportation routes Their precise locations are due to a combination of landforms, water bodies, and

historical events In West Saginaw, the original nucleus of the whole city, there is a fairly active but rather small business section It is the commercial core of East Saginaw that is the real business center of the present city (Pl LXV, Fig 2) Several new sky-scrapers in East Saginaw add a distinctly modern touch to the sky line, and attest not only the growth of Saginaw generally, but also the development of East Saginaw as the commercial nucleus of the whole metropolitan area

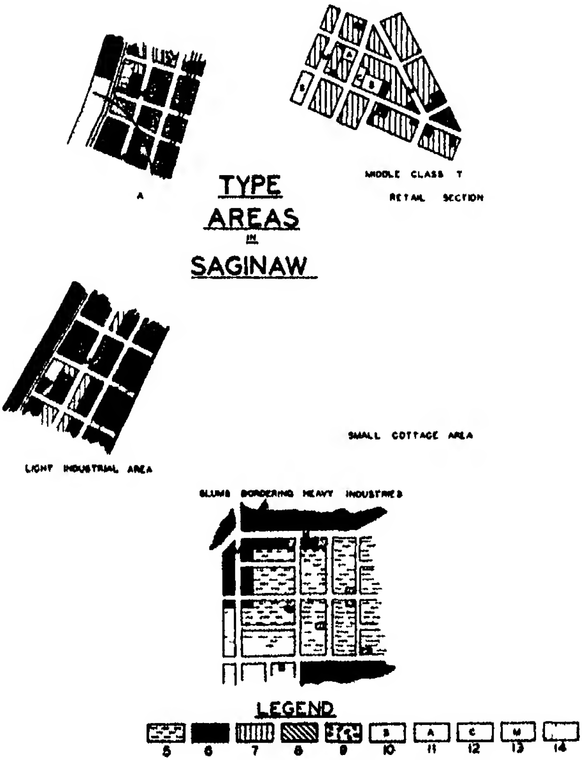
Most of the lighter industries are located along the railroads in closely built parts of the city The heavy manufacturing plants are found (1) along the river, on land that has been largely filled in, (2) in the northern part, where the land is low and poorly drained (Pl LXVI), (3) in the south, where low land again occurs, and (4) on the outskirts of the city along main railroad lines Because of the large amount of poor land and the many railroads there is a super-abundance of industrial property in Saginaw (Map 7)

The poorest residential sections of the city, the slums, fringe the river or railways, adjoin manufacturing areas, or occupy land which, because of poor drainage, occasional overflows, or heavy smoke, is unsuitable for better homes The largest section of slums is in the northern part of East Saginaw near the Pere Marquette Railway shops and the Chevrolet Motor Company plant, which have attracted large numbers of Negroes and Mexicans to that part of the city

Cottage areas are more extensive in Saginaw than is any other sort of residential district, occupying about 15 of the 24 per cent of land used for residential purposes They have grown up mainly (1) on lower land undesirable for high class residences, (2) near factory sites, and (3) in an irregular zone which extends around the city at such a distance from the business centers that the land included in it is relatively low in price and not highly restricted Most of the homes in Saginaw were built during the years of the lumber boom, and consequently reflect the style of that period Owing to the small size of so many homes, built during that period, over 65 per cent of the families in Saginaw own their own homes [3]

Homes ranging from middle class to superior or exclusive are found in the higher, more desirable localities, such as the shady

[3] *Fifteenth Census of the United States 1930*, "Population," Vol VI, "Families," p 31



MAP 7 Parts of the sections of Saginaw discussed in the paper The key t the legend is as follows

1 Local business
2 Light industries
3 Heavy industries
4. Railroad property, freight stations, depots, etc
5 Slums
6. Small cottages
7 Middle-class residences
8 Superior residences
9 Wholesale houses, warehouses
10 School
11 Apartments
12 Church
13 Main highway
14. Vacant property

moraine area south of the business district of East Saginaw, and along main thoroughfares Proximity to the business district is no longer an essential to good residential property, rather, rapid transportation has made the land along or just off the main highways at a considerable distance from the center of town a highly desirable location for good residences Some of the most modern high-class homes are not far inside the city limits, and it is probable that considerable growth will take place in these sections in the future

In and about the areas that have been described are a number of pleasant parks and playgrounds located with hardly an exception near well-to-do residential districts and in spots of unusual scenic beauty, while out beyond the city proper is the suburban area, made up in some places of subdivisions of single lots and in others of farms of various sizes

The future of Saginaw is mainly dependent upon the stabilization of the newer industries which have come into existence since the decline of the lumber business Although a few of these enterprises have failed, the increasing number of smaller industries seems to indicate that conditions are becoming more settled

The effect of the St Lawrence waterway project upon the future of Saginaw is problematical There are a number of companies that export products to foreign countries, and it is probable that a deep waterway will be beneficial to them The Saginaw River has already been dredged to allow large lake boats to come to Saginaw, and further deepening will make it possible for ocean steamers to reach the city It might be thought that Bay City, since it is closer to Saginaw Bay than is Saginaw, would have a decided advantage and would become the main port of the Saginaw Bay region However, Saginaw has already firmly established itself as a trading center of the valley, whereas Bay City is on the periphery of the area It is therefore entirely probable that this condition will offset much of the disadvantage which the upstream location of Saginaw might offer Thus though railways and motor cars will continue to care for local and regional transportation very much as they do at present, the new waterway will enable the city to enter into commercial relations with other parts of the world That this is expected is indicated by the fact that water-front property has risen in price within the last few years It is doubtful, however, whether there is enough in the hinterland to warrant the belief that the proposed

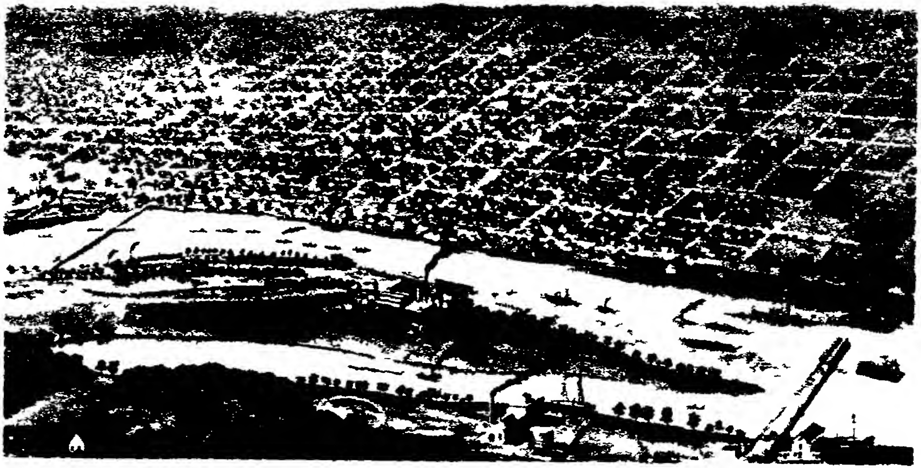
waterway will establish Saginaw as an important ocean port or will afford any unusual impetus to industrial activity

There is every indication that Saginaw will continue to be a city of diversified industries, and it may enter into world relations to a limited extent There is no reason to believe, however, that it will increase much in either size or importance in the future, although it will probably always remain the key city of the Saginaw Valley

WAYNE UNIVERSITY
DETROIT, MICHIGAN

PLATES LXIV–LXVI

PLATE LXIV



View of West Saginaw in 1850 showing the large island which prevented a village from springing up across the river. Note the many docks and sawmills. From a print owned by Mrs. John Spencer who resides in Saginaw.

PLATE LXV

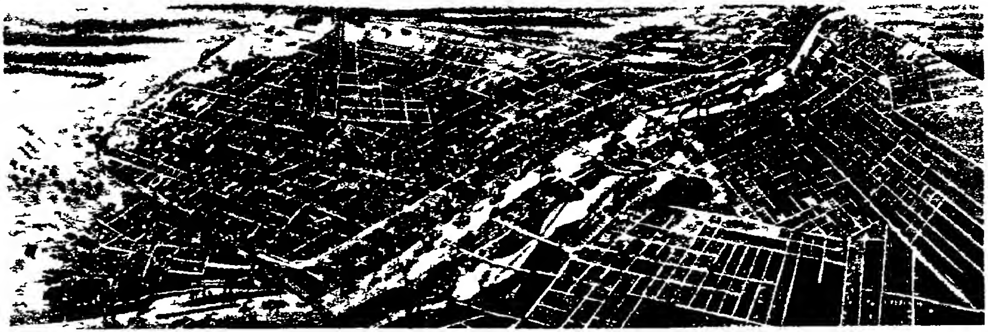


FIG. 1. View of the Saginaws in the nineties looking to the southeast, from *History of ... of Saginaw* [1896], p. 62

FIG. 2. Skyline of East Saginaw

PLATE LXVI

Low swampy land such as that shown in this picture is found in the northern part of Saginaw. The buildings seen in the distance are those of the Chevrolet Motor Company.

THE LAKE ST JEAN LOWLAND, PROVINCE OF QUEBEC *

ROBERT M GLENDINNING

INTRODUCTION

THE earliest geographical knowledge concerning the area bordering Lake St Jean emanates from Père Jean de Quen, the first white man to view the great lake which is the source of the river Saguenay (Map 8)

Père de Quen, with two savages as guides and canoemen, left the little Indian village of Tadoussac at the mouth of the Saguenay in August, 1647, and began the westward journey up the rock-walled river The small party left the great river at the present site of Chicoutimi to follow the course of the river of that name up to Lake Kenogami (Map 8) They paddled westward on this lake to its end, where the canoe was carried overland to the small body of water called Kenogamichiche (Lake Vert, see Map 9) Without encountering further obstacles they continued across this lake and down a tributary of the Belle River to its mouth on the southeastern shore of Lake St Jean, reaching there on the second day of September, 1647 [1]

Several other men, chiefly Jesuits, followed closely on the heels of Père de Quen, among them Père Gabriel Drueillettes and Père Claude Dablon, in the summer of 1671 [2] Père Charles Albanel visited the area on his famous journey to Hudson Bay in 1671 [3]

From descriptions left by these intrepid men, as well as by many

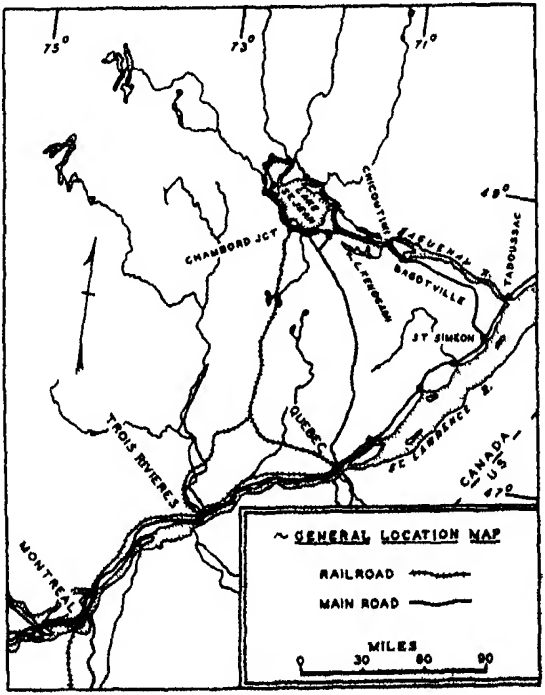
* This paper is a curtailed form of an unpublished article of the same title The field work on the area was done in the summers of 1931 and 1932 The use of "St Jean" in preference to "St John" is followed in the attempt to preserve the original name and to avoid the incongruity involved in employing the English form in juxtaposition with the primarily French nomenclature of the area Other reasons, for which there is no space here, also enter into this usage

[1] Thwaites, R G, editor, *Jesuit Relations and Allied Documents* (Burrows Bros. Co, Cleveland, 1898), 31 250, 252 [2] *Ibid*, 46 261

[3] *Ibid*, 56 155

more,[4] it is possible to reconstruct, in a general way, the landscape expression of the region at the time of the advent of the white man

The focal point of the picture is occupied by a large, elliptical lake bordered by a relatively level plain, which in turn is surrounded by

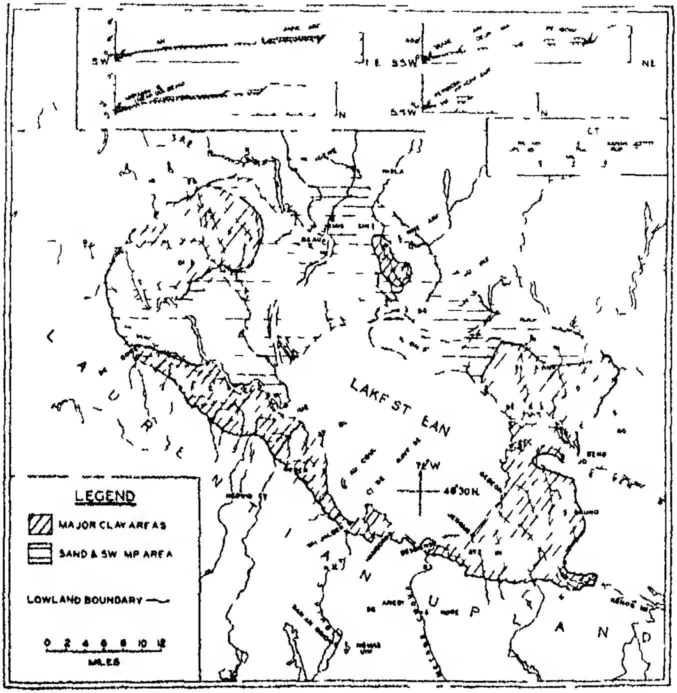


MAP 8. Lake St Jean, the Saguenay, and the St Lawrence

hilly uplands of solid, glaciated rock From the highland many large rivers descend from nearly all directions to replenish the great natural reservoir The lake receiving these copious waters has but one outlet, a double one, through which the waters rush and tumble

[4] Thwaites, *op cit*, 68 41 See also de Rochemonteix, Le P Camille, *Les Jésuites et la Nouvelle-France au XVII*e *siècle* (Letouzey et Ané, Paris, 1896), 3 413

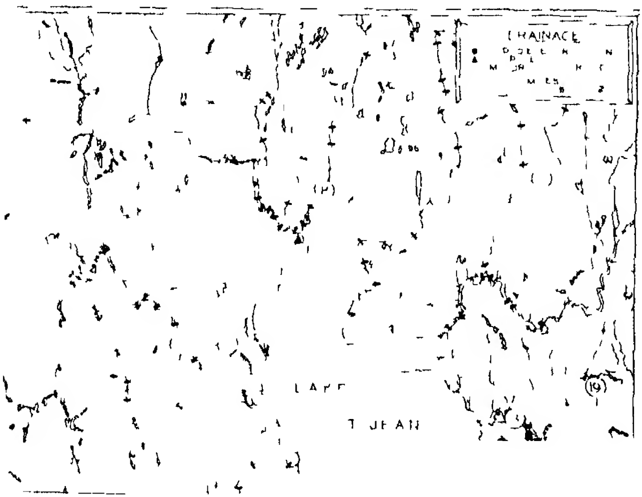
as they race eastward in their gorges to form, at their junction, the river Saguenay (Map 10) An extensive forest, dominantly coniferous, cloaked the lowland and spread up into the highland, where



Map 9 Land divisions of the St Jean Lowland Based on field work, correspondence with members of the Geological Survey of Canada, Royal Canadian Air Force photographs, and reference maps 1 and 10 (see p 341) Transects (insets) adapted from A Graham, Land Classification North of St John (unpublished), obtained through the courtesy of the author

its mantle was broken by barren, glacially smoothed hills In the woodland lived many animals, such as the moose, bear, otter, beaver, and porcupine. The waters of the lake and streams harbored an abundant fish life, made up of such species as trout, salmon, perch,

pike, and carp In this primitive setting moved the Indians, using the streams as their highways, the lowland shore at certain spots as summer meeting places, and the immense spaces of the upland for the winter activities of hunting and trapping Among the Indians a



MAP 10 Based on reference maps 1 3 and 5 (see p 341)

few Jesuit priests pursued their dangerous and difficult work of evangelization and already the buyers of pelts came to the summer trading places to leave their guns, blankets and trinkets in exchange for the prime furs garnered the preceding winter

A broad view of the area at the present time gives a picture which, while not totally different shows considerable metamorphosis This change has been wrought chiefly during the last eighty years by

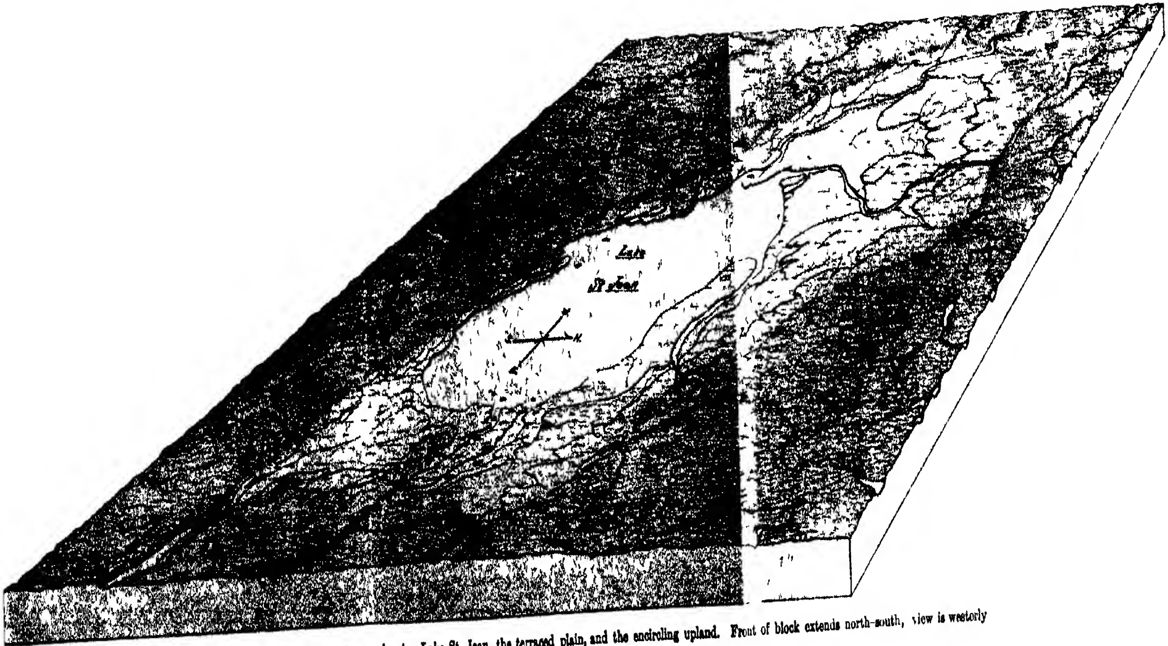


FIG. 5 Generalised block diagram showing Lake St Jean, the terraced plain, and the encircling upland. Front of block extends north-south, view is westerly

the French-Canadian agriculturist with his land-clearing and crop-planting activities The lowland is now largely cleared, especially to the east, south, and west of the lake This land is occupied by long, narrow fields which stretch back from the roads that thread the plain With the clearing have come the crops, the domestic animals, the fences, the lines of roadside buildings, and the retreat of wild animal life But, surrounding this region of change, the dark forest, little broken by the thrusts of human beings, looks down from the plateau and over large areas to the north of the lake still disputes with the farmer for possession of the plain

The Terrain

A DESCRIPTION OF THE NATURAL PORTION OF THE LANDSCAPE

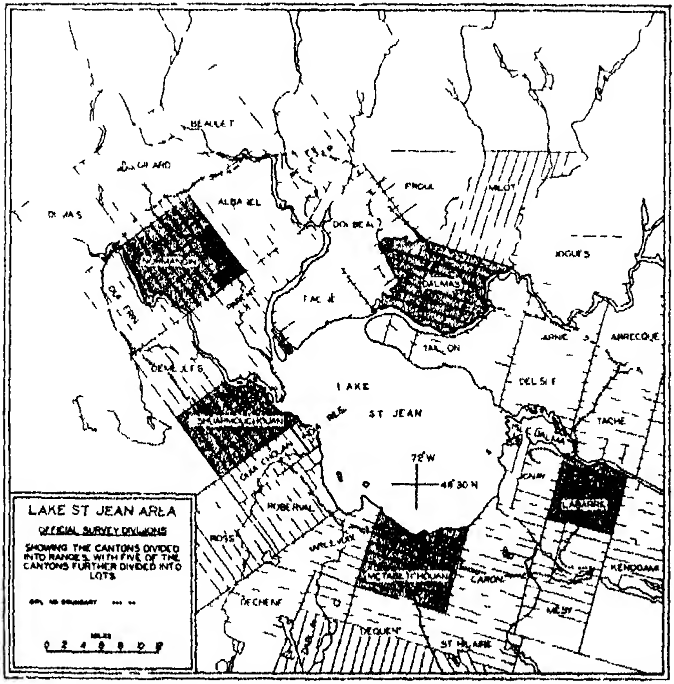
Surface and drainage — Between the low shores of the lake and the base of the encircling upland there are terraces which rise in broad, shallow steps They are composed of unconsolidated sands and clays that were deposited, during Champlainian times, in an arm of the sea which reached westward through the Saguenay trough and drowned the basin in the lowest portion of which the lake now lies It is these depositional features that constitute the plain (Fig 5 and Map 9) [5] There are three terrace levels, although the upper one is in many places fragmental The edge of each of these terraces marks a stage in the withdrawal of the sea waters from the lowland The lake-facing edge of the lower terrace has an altitude, with reference to present sea level, of approximately 345 feet, the second, 360–370 feet, and the third, about 500 feet [6] However, the treads of the terrace steps are not horizontal, rather, each one rises at a very slight angle from its edge to the base of the next, so that the actual step-up, depending on locality (Pl LXVII, Fig 1), is only some twenty to forty feet

Within the plain there are lesser landforms which merit attention Numerous streams have eaten their courses into the soft ma-

[5] Dresser, John A , *Part of the District of Lake St John, Quebec* (Gov Print Bureau, Ottawa, 1916), Memoir 92, Geol Ser No 74 4, 48 See also Blanchard, Raoul, "Le Saguenay et le Lac Saint-Jean," *Rev de géog alpine*, 21 26–33 1933

[6] Dresser, *op cit* , p 3 See also Montgomery, R. H , *Precise Levelling in Quebec North of the St Lawrence River* (Acland, Ottawa, 1929), Geodetic Survey of Canada, Publication No 18, and Sinclair, G E B , "Bench Marks between St. Félicien and Isle Maligne, Quebec, Via Provincial Highway No 15, around North Side of Lake St John," unpublished, 1929

terials, with the smaller ones producing deep, youthful gullies, and the larger ones, broad lanes of water flanked by low shores that are swampy in places (Pl LXVII, Figs 1–2) Northeast of the lake there is an area in which outcrops of glacially polished rock hills



Map 11 Based on reference map 1 (see p 341)

are plentiful, extending from the lake edge through the eastern part of Canton Taillon and the western part of cantons Delisle and Garnier to the upland (Map 11, Pl LXXII, Fig 1) Southeast of the village of St Prime (Map 9) there is a pronounced ridge, the Côte St Prime, which extends from Pte Bleue in a southwesterly direction to the base of the upland [7] It presents an escarpment nearly

[7] Dresser, *op cit*, pp 27–28

one hundred feet high to the lowland about St Prime (Pl LXVII, Fig 3) Toward the lake the escarpment lowers gradually to Pte Bleue, and from the crest, where pre-Cambrian rocks are much exposed, it slopes gently to the southeast, merging imperceptibly with the general terrace level which overlaps it on that side (Pl LXXII, Fig 2) Between Val Jalbert and Chambord (Map 9) there are two small ridges the Côte Pte aux Pins and the Côte Chambord They owe their existence to upraised portions of the bedrock which extend from the base of the upland in a northwesterly direction to the lake The extension of this structure can be traced in the Isle aux Couleuves and the Isle de la Traverse (Map 9) The Côte Pte aux Pins follows this trend, dipping gently to the lake Its shape is much like that of a shallow, inverted canoe and, unlike the Côte St Prime, there is no escarpment It is mantled with the soft materials that comprise the plain The Côte Chambord is like its neighbor in trend and shape, differing from it in being larger, in not quite reaching the lake, and in having near its top a thinner mantle of deposits, so that bedrock is exposed in the watercourses and along roadside ditches Both these forms vary in altitude from about 350 feet at their lakeward ends to over 500 feet where they join the upland Other interruptions to the lowland plain are minor ones At certain places glaciated bosses protrude from the general level [8] They are like the rock hills which occur in greater profusion in the area mentioned, to the northeast of the lake These outcrops occur in the plain between the Belle River and the Décharges, northwest of the village of St Prime and just south of Normandin (Maps 9 10) To the north, along the outer edge of the lowland proper, they become so numerous as to warrant the inclusion of the area in which they occur as part of the upland landscape In addition, there are near St Jerôme two kames which resemble large, partly submerged whales with their heads pointed to the northwest (Map 9) [9]

The edge of the encircling higher land varies in altitude from place to place but even at the lowest points it forms an easily discernible rim against the horizon Along the southern edge of the lowland, from Lake Vert to the Ashuapmouchouan River, the rim appears from below as a forested wall which rises as much as five hundred feet above the plain in the east and descends gradually westward (Map 9, Fig 5, Pl LXVIII, Fig 1, Pl LXXIII, Fig 1) [10] The

[8] *Ibid*, p 27 [9] *Ibid*, p 45 [10] *Ibid*, p 4

eastern rim of the basin is lower and more broken, and is deeply indented by eastward-reaching fingers of the plain (Fig 5, Pl LXVII, Fig 2, Pl LXXIII, Fig 2) The northern border of the lowland is the least conspicuous and, like the eastern rim, has terrace tentacles which invade for considerable distances, particularly along the stream courses When seen from afar, however, it appears well marked, and only as one approaches closely is it found to be less sharply defined This northern boundary has been drawn where the rock outcrops become plentiful enough to give one the impression of the plateau landscape, or, in other words, at the edge of the *lowland proper*

In essence, then, the surface of the region consists of a large lake bordered by clay and sand terraces, which are in turn flanked by a glaciated upland

Lying on, or deeply cut into, the surface are the features of the drainage These hydrographic elements, of which Lake St Jean is the most conspicuous, are composed of lakes, streams, and swamps With the recent completion (1926) of dams and barrages at the Décharges the outflowing waters of the lake are controlled to prevent the former fluctuations in level between late summer and spring, and hence to insure a known minimum for the development of hydro-electric power [11] This body of water, of oval shape, presents a vast blue expanse in summer and a plain of snow-covered ice in winter The Indians knew it as "Piougamik," signifying "flat lake" in their tongue [12] Its waters are shallow and dotted with small islands, most of which lie in the eastern portion near the Décharges (Map 9) The shore is generally low, so low at Roberval, for example, that a small "sea wall" has been constructed to protect the edge of the lower terrace from storm waves Where the Côte St Prime reaches the shore at Pte Bleue, stony headlands, twenty to forty feet in height, front the water The northern shore west of St Henri de Taillon is swampy, except here and there where recent wave-cutting has produced low but sharp embankments The same type of erosion has resulted in a steep terrace face, at some points fifty feet high, betweeen St Jerôme and Pte de la Traverse Southwest of St Gédéon

[11] *Industry in Saguenay and Lake St John District* (Price Bros & Co, Ltd, Chicoutimi, n d) See also Dresser, *op cit*, p 10

[12] *Le Saguenay et le Lac St-Jean Ressources et avantages qu'ils offrent aux colons et aux capitalistes* (Département de l'Agriculture, Ottawa, 1879), p 10

for about three miles the shore is low and sandy The presence of a sandy beach there has led the inhabitants to refer to it, somewhat facetiously, as the "Palm Beach" of the Lake St Jean area

The other lakes of the lowland are few and small, Lake Vert is the largest Where these areally insignificant water bodies do occur they lie at, or close to, the base of the upland (Map 9) In the glaciated highland lakes are very numerous - a decided contrast to the condition in the plain (Map 10)

The drainage pattern of the region is in a sense obversely radial, for into the lake as a hub flow many rivers from practically all directions (Map 10) To be sure, the outlet (the double one of the Décharges) to the east has its waters flowing away from the lake, but even that line acts as a spoke in the radial pattern The river Peribonca, the longest of the streams, has its source some three hundred miles back in the plateau to the north, it pursues a course through rocky gorges and over innumerable falls and rapids to tumble finally into the lowland near Honfleur (Pl LXIX, Fig 1) From this point it forms a broad, sluggish stream to its mouth at the north-central shore of the lake (Pl LXVII, Fig 2) Its western neighbor, the Mistassini and its tributaries, is two hundred miles long Below Dolbeau (Map 9) its waters are broad and placid, but above it flows over a series of rock ledges exposed as it dug itself into the soft materials of the lowland (Map 10) In the upland its course is torrential The river Ashuapmouchouan (also Chamouchouan) is in all essentials similar to the Mistassini Just south of Val Jalbert the Ouiatchouan plunges two hundred and forty-nine feet over the edge of the escarpment and then rushes across the constricted portion of the plain to the lake (Pl LXIII, Fig 1) At the settlement of Desbiens the Metabetchouan joins the lake and forms near the mouth an embayment behind which several falls and rapids mark its course back into the highland (Pl. LXIX, Fig 2) The Belle River descends the upland rim southwest of Hébertville and then trends northwest to the lake One of its tributaries, the Aulnets, drains Lake Vert and is the route that was used by Père de Quen in crossing the lowland There are several small falls in its path through the lowland where it, like many of the other streams, has exposed the rock basement The lake itself pours its waters to the east through the island-dotted gorges of the Grande and the Petite Décharges (Map 10) The two Décharges join downstream from the

town of St Joseph d'Alma to form the upper Saguenay From the lake to tidewater on the Saguenay, a distance of some thirty miles, the waters descend more than three hundred feet A study of Map 10 will indicate that there are many lesser streams crossing the lowland, all of which tend to emphasize further the roughly radial pattern pointed out above Some are much smaller than others and their sources may or may not tap the upland

Between the stream lines the adequacy of drainage of the lowland varies greatly from place to place The predominantly clay areas (Map 9) are as a whole well drained by large and small streams with their tributary gullies, although there are small, infrequent patches where the nearly level clay surface is not tapped sufficiently well by stream lines to insure rapid run-off from the impervious materials The major portion of the "non-swamp" area lies to the northeast, east, south, and southwest of the lake, in addition there are two large outliers along the upper Ticouapé River and the middle part of the lower Petite Peribonca With the exception of these two areas, the lowland to the north of the lake is a conglomeration of sand-plains and swamps It may be thought of as a swamp country in which there are islands, large and small, of sandy plain The fact that the clays are relatively well drained and the sandy areas poorly drained seems contrary to logic until it is known that the sandy portions are directly underlain by clays which hinder or prohibit the downward movement of ground water — thus insuring swamps where the sand mantle is thin and "islands" where it is thicker Also, the porous sands have probably lessened the amount of run-off and hence have hampered the development of an elaborate drainage system (contrast the upper portion of the Ticouapé basin, in the clay, with the lower portion which lies in the sand, as shown in Maps 9–10) The wettest part of the sand and swamp country occupies the Taillon Peninsula, the land between the mouths of the Peribonca and the Mistassini, and the lower part of the Ticouapé basin as far west and south as the Ashuapmouchouan Canton Racine (Map 11) is practically all swamp However, as one reaches the higher ground, toward the upland, the swamps decrease in size and number, to the gain of the sand-plains The raising of the lake level by the power company has somewhat enhanced the swampiness of the area, particularly near stream mouths

Soils — The soil mantle of the plain owes its major characteris-

ties to the events which occurred during the Champlainian submergence, but since then certain factors, chiefly drainage conditions, have slightly altered the edaphic set-up The lowland soils vary from compact, gray clays to porous, yellowish sands The clay areas have some few patches in which there is a thin accumulation of peaty materials over the impervious loams Where the kames occur, near St Jerôme, the soil is a loose collection of sand, gravel, and glacial boulders In the case of the Côte St Prime, bedrock is exposed along the crest and in small outcrops near the upper part of its southeastern slope, and also here and there in the plain, as already mentioned, where polished basement rock protrudes Narrow valley bottoms, lying below the general level, possess bordering threads of alluvium In the sand and swamp area the dominant soil is sand, with an occasional admixture of sandy loam Over large tracts peaty swamp mucks occur on top of and encompassed by the lighter soils Also in this sand and swamp country are the two large areas of clay loam referred to above The soil mantle of the plain reaches depths of from one hundred to two hundred feet in places, while in others the basement complex is laid bare [13] The upland soils are in decided contrast, for at the base of the rim there is usually a sudden change from thick marine deposits to a thin and patchy mantle of glacial materials (Pl LXXIII, Fig 1) The soils of the entire region are distinctly immature — undoubtedly an association with their recent origin together with the sluggishness of the soil-maturing processes in an area with long, severe winters and short summers (Table I)

Vegetation — Under former conditions the plain supported a forest growth throughout [14] The area is located, in terms of vegetation, along the southern margin of the "Northern Forest Belt" of Canada, with its southeastern edge touching the "Transitional Belt" [15] Conifers make up the bulk of the forest, with, in addition, a sprinkling of broad-leafed trees The upland still preserves the appearance of a conifer sea, broken only by recent burns, rock outcrops, and pulp-wood slashings (Pl LXXIII, Fig 1) The forest of

[13] Dresser, *op cit*, p 45

[14] *Ibid*, p 16 See also *Report of the Commissioners for Exploring the Saguenay* (Neilson & Cowan, Quebec, 1829) See, in addition, the references cited in the footnotes to the introduction to this paper

[15] Craig, Roland D, "Forest Resources of Canada" *Econ Geog*, 2 394–413 1926

the plain has undergone marked modification because of the "Great Fire" of 1870 [16] and the clearing of the land by the farmers The clay areas have been practically stripped, although new growth is apparent along the valley sides and the lake shore, as well as in the infrequent swampy patches The Côte St Prime is forest-covered, chiefly that portion toward the Indian Reserve at Pte Bleue (Pl LXXII, Fig 2) In the sand and swamp areas the picture is one of contrast, with most of the land still in forest of one sort or another Areally inconspicuous clearings have been made in these parts, some of them very recent (Pl LXX, Fig 1) and others marked by farm abandonment, they are confined to the sides of the main roads This forest presents an extremely complex pattern composed of spruce and tamarack swamps mixed with jack-pine plains (Pl LXX, Figs 2-3, Pl LXXI, Fig 1) In the higher parts of the northern plain the jack-pine plains become dominant, although even here there are numerous and often extensive patches of the swamp associations Recurrent burning of the drier parts has resulted in a jack-pine association made up of this scrubby pine and poplar, birch, pin cherry, and maple, with a ground cover of bracken, reindeer moss, and blueberry (see pp 339-340 for a list of trees and smaller plants) In addition to covering most of the sand and swamp area, the forest continues on into the upland — a contrast to the condition where the clays border the plateau

Climate — Overlying the natural factors so far described is a set of atmospheric phenomena pertinent to this inquiry into the landscape of the lowland The climate is characterized by long, severe winters and short, warm summers (Table I) [17] Precipitation varies from a low of 1 4 inches in March to a high of 3 6 inches in July The prevailing winds are westerly, being southwesterly in summer and often northwesterly in the spring and fall As a result of the cold-season temperatures the streams are icebound from six to seven months each year in the lowland and for a somewhat longer period in the higher lands At this time the lake is a great sheet of snow-covered ice, with its level tending to fall until the spring "break-up" Meanwhile the conifers stand clothed but dormant, while the decid-

[16] Audet, François J , *Canadian Historical Dates and Events* (C Beauregard, Ottawa, 1917) See also Dresser, *op cit* , p 16

[17] The climate is Dfb, according to Köppen, W , *Die Klimate der Erde* (Berlin u Leipzig, 1923)

uous trees are barren, and the land, like the lake, is mantled with deep snows The effect of the climate on man's activities will be discussed later, but from the foregoing meager description it may be seen that atmospheric conditions play a large part in the seasonal behavior of the milieu of those activities

TABLE I

CLIMATIC STATISTICS FOR ROBERVAL, LAKE ST JEAN

(Obtained from the Meterological Service of Canada, Toronto)

Temperature (Fahrenheit)	Ten year average												
	J	F	M	A	M	J	J	A	S	O	N	D	Yr
Mean temperature	0	2	19	35	50	60	66	62	53	41	25	10	35 2
Mean daily max	11	14	30	44	60	69	76	73	63	50	32	17	
Mean daily min	−10	− 9	8	26	39	50	56	52	43	33	18	3	
Absolute max	47	49	66	72	89	95	97	93	90	80	65	47	
Absolute min	−44	−36	−25	− 2	18	29	40	34	24	16	−11	−46	
Precipitation (inches)													
Rain	0 1	0 1	0 4	1 9	2 4	3 4	3 6	2 4	2 9	2 3	0 9	0 4	
Snow	15	14	10	4	1	0	0	0	0	2	9	17	
Total precipitation	1 6	1 5	1 4	2 3	2 5	3 4	3 6	2 4	2 9	2 5	1 8	2 1	28 0

THE OCCUPANCE

A DESCRIPTION OF THE CULTURAL PORTION OF THE LANDSCAPE

So far, the picture of the region lacks the human element in any great detail and consequently the multiplicity of forms that are associated with human settlement

The Origin of the Present Conditions

The Indians —Prior to the arrival of the Europeans the Indians held sway over the lowland and the adjacent vast plateau country However, the insecurity of their foothold on the plain and the small degree of modification accomplished by them is illustrated in the fact that today they are represented only at the Pte Bleue Reserve (Map 9) There they spend a leisurely summer, which is followed by the winter activities of hunting and trapping in the upland In the

late spring they return with their furs to the Hudson Bay Company's post at the reservation

The missionaries — In the seventeenth century the Jesuits appeared on the scene, extending the work of the Church from Tadoussac, up the Saguenay, into the lowland, and beyond toward James Bay Their first permanent establishment in the plain was at Metabetchouan (Desbiens, see Map 9), St Charles Mission, on the right bank, near the mouth, of the river of the same name This was in 1665 [18] From such humble beginnings the work of the Church has continued until today the spires of the houses of worship rise high above every settlement in the region (Pl LXVIII, Fig 1, Pl LXXI, Fig 3)

The fur traders — Along the trail blazed by the Jesuits came the traders in furs, at first with no permanent posts, but later with posts at Chicoutimi on the Saguenay, at Metabetchouan, Pte Bleue, another on the Ashuapmouchouan, and still others toward Hudson Bay [19] The lucrative trade in pelts resulted in the region being closed by law to other activities, until the clamor of public opinion and governmental inquiry, beginning about 1825, ended in colonization activities, which were in full swing by mid-century [20] The only remnant in the plain of this great fur-gathering era is the little post at Pte Bleue

The lumbermen — The work of the Church and the trading companies gave notice of the great pine forests of the Saguenay, so that by the opening of the nineteenth century the lumbermen were pushing their way up the great river So far as the lowland itself is concerned, the lumbermen were of importance in calling attention to the large amounts of arable land bordering the lake, although the modern counterpart of their work is represented by the pulp and newsprint mills at Dolbeau, Riverbend, and Desbiens (Maps 9–10) Difficulties in transportation and the forest fire of 1870 doomed to failure any large lumbering operations in the plain

The colonist-farmers — The great modification of the lowland began with the first permanent agricultural settlement at Hébertville (Map 9) in 1851 Two years before, M l'Abbé Hébert, heading

[18] Thwaites, *op cit*, 60 322

[19] *Ibid* 69 111 See also *Le Saguenay et le Lac St-Jean* , pp 3–4

[20] *Le Saguenay et le Lac St-Jean* , p 5 See also *Report of the Commissioners for Exploring the Saguenay*

a society of colonization, secured from Parliament the right to develop the southeastern part of the plain [21] He followed this with preparatory work which led to permanent occupation, using De Quen's old route via Lake Kenogami in order to avoid the Décharge rapids From this origin in the southeastern corner the French-Canadian settlers, derived from the St Lawrence littoral, have spread westward and northward until now, in varying numbers, they encircle the lake (Map 13, p 338)

The Present Conditions

Inasmuch as this spread of population, with all that it entails, has taken place through the slow extension of the road and, because the road is at present the artery along which the life of the region courses, it is proposed to deal with the road pattern first, taking it as a unifying concept by means of which the associated phenomena may be described

The road — The first roads built in the lowland were in the vicinity of Hébertville [22] One of these connected Lakes Kenogami and Kenogamichiche (Lake Vert), and Kenogami was in turn tied to the settlements on the middle Saguenay During the 'seventies a road was extended westward, south of the lake, to the Ashuapmouchouan The less desirable lands, to the north of the lake, secured roads at later dates and even today there are large gaps in the road pattern there (Map 12) Many of the roads were for a long time without bridges over the larger streams, a ferry or, in winter, the ice had to be used at these points [23] Temporary routes developed on the lake ice, for example, it was common for the inhabitants of the village of Peribonca to drive their sleighs directly across the lake, some twenty miles, to Roberval in order to procure supplies and mail This was done until 1926, when the railroad was completed to Dolbeau At present it is possible to drive an automobile entirely around the lake during the warmer season, in the winter, however, the snow and cold demand the use of sleighs

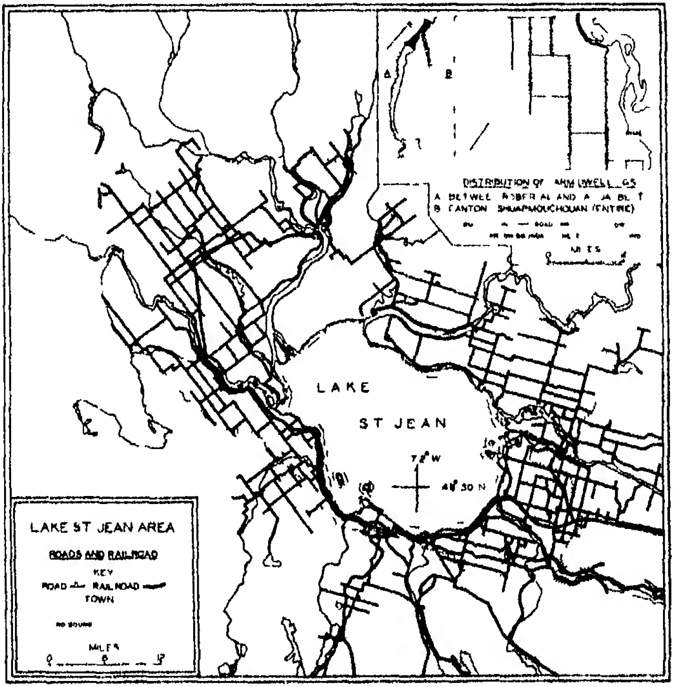
Except in the relatively few instances in which the conditions

[21] Laliberté, Abbé André, *Les Fêtes du Monument Hébert, Hébertville, Lac Saint-Jean, 6 Juillet, 1926* (Le Syndicat des Imprimeurs du Saguenay, Chicoutimi, 1926), particularly pp 17-25 See also Blanchard, *op cit* pp 78 89

[22] *Le Saguenay et le Lac St-Jean* , p 10

[23] Hémon, Louis, *Maria Chapdelaine Récit du Canada français* (Bernard , Paris, 1924), pp 25-27 See also Blanchard, *op cit* , pp 89-94

of drainage or of surface do not permit, the roads are laid along the lines of the survey This relationship is so close that it is necessary to describe the survey pattern before taking up the details of the road pattern The region is divided into cantons, ranges, and lots,



MAP 12 Based on field work and reference maps 1–4 and 9 (see p 341) The inset is based on plane-table work by the author

in order of decreasing size (Map 11) The cantons radiate from the lake in varying sizes and shapes but, regardless of area or form, each one is divided into long strips, usually one mile in width, known as "ranges" Each range is in turn divided into smaller strips, at right angles to its trend, ordinarily one mile in length and one sixth of that distance in width — these are called "lots" This strip system of

survey was taken directly from the old French settlements along the St Lawrence,[24] where the idea was to have as many farms as possible fronting the water It has resulted in certain irregularities in the areas and the trend of the lots in the Lake St Jean region, as shown in Map 11 The vast majority of the roads follow either range or lot lines (compare Maps 11 and 12), so that the line of the highway is very straight until a turn is reached, when it forms a right angle and then proceeds to the next turning As a consequence, the roads produce a sort of broken spiderweb pattern, which is broken because of the lake, and the absence of roads in most of the sandy or swampy areas (compare Maps 9 and 12)

Conditions of drainage or of surface may cause local deviations from the survey lines or force the roads away from certain portions The occurrence of small lakes, as Lake Vert, necessitates a bending of the highway around their shores In other places, as at Desbiens, the valleys are of sufficient depth to cause the road to desert its straight line in the attempt to find a crossing Where rock outcrops are numerous, as northeast of the lake, the thoroughfare is forced to deviate, although its linear and rectilinear quality is still discernible (Pl LXXII, Fig 1) Where the larger streams become very broad, the roads seek narrower crossings far upstream, as at Dolbeau, Honfleur, and St Félicien The Grande and Petite Décharges are easily bridged only in their narrow eastern courses at a considerable distance from the lake The entire absence of roads in Canton Racine is a reflection of the swampy condition of the area between the Peribonca and Mistassini river mouths Outside the lowland the roads become mere tentacles leading for varying distances into the plateau country

In addition to the road in the ordinary sense of the term there are the other kinds of roads, or "ways," viz the railroads and the water roads The railroad from Quebec enters the lowland at Chambord Junction (Map 8) From this place one branch goes west around the lake to Dolbeau, another east to Chicoutimi and Bagotville In the eastern part of the lowland a short-line tentacle joins the eastern branch to the Décharges (Map 12)[25] The water roads are

[24] Miller, Émile, *Terres et peuples du Canada* (Librairie Beauchemin, Montreal, 1912), notes on pp 30, 32, 108 See also Munro William B, *The Seigniorial System in Canada, A Study in French Colonial Policy* (Longmans, Green & Co, New York, 1907), especially p 24

[25] Contrary to the Standard Topographical Map, Quebec, Roberval Sheet, Sheet 34 (Ottawa, 1929), the railroad does not extend to the lower falls of the Peribonca

the rivers and the lake The Ashuapmouchouan, Mistassini, and Peribonca are used by the Indians in their seasonal migrations to and from the upland, and the lake enables their canoes to reach the reserve at Pte Bleue Spruce bolts, for making pulp, travel down the Mistassini and Metabetchouan particularly, journeying from the forests of the upland to the lake, where small steam tugs pick up those at the mouth of the Mistassini and raft them across the lake for the mill at Riverbend (Pl LXIX, Fig 2, Pl LXXIV, Fig 1) During the ice-free season there is some nonschedule movement of persons and goods by small lake boats, but this latter phase is of decreasing importance since the extension of the railroad to Dolbeau, it has taken on the aspect of Sunday excursions, chiefly between Roberval and Peribonca (Pl LXVII, Fig 2)

Road connections with the outside world are few (see Map 8) The railroad joins the lowland with Quebec to the south and with Bagotville and Chicoutimi on the Saguenay tidewater The highway to Chicoutimi continues to St Siméon on the St Lawrence, although its narrowness and steep grades help in the isolation of the lowland Another road connects the southeastern part of the plain directly with Quebec This "road," a somewhat improved version of the old Quebec–Lake St Jean Trail,[36] leads the traveler a rough and winding chase through the Laurentides Park

The agricultural forms associated with the road — Closely related to the highways are many apparent landscape features In the clay areas, where roads are more numerous, these features are dominantly cultural, whereas in the sand and swamp portions they are chiefly of natural origin The outstanding cultural element connected directly with the road is the farm Along with the farm go the agricultural people, the buildings of the farmstead, the crops, and domestic animals

Each farm occupies a strip of land which fronts on the road and extends at right angles to it This strip arrangement, originating in the survey system, causes one end of the farm to touch the highway and the other to lie one mile from it It is further stressed by the common practice of dividing the farm into two or more strip fields, oriented with the lines of the main strip (Pl LXXIV, Fig 2) The result of this is the transformation of the cleared parts of the plain

[36] Davenport, Mrs , *Journal of a Fourteen Days' Ride through the Bush from Quebec to Lake St John* (Daily Mercury Office, Quebec, 1872)

into a succession of long, narrow fields, equally conspicuous from the ground or the air Another result is the placing of the farmstead directly contiguous to the road, for there are the place of egress and also, when heavy snows mantle the land, the location which facilitates the gaining of the highway by the horse and sleigh Other factors difficult to evaluate, such as gregarious tendencies, undoubtedly enter into this hugging of the road (Pl LXXI, Fig 2, Pl LXXIII, Fig 2) The buildings of the average farmstead comprise a farmhouse, a barn, a wagonshed, an outdoor oven, and small sheds for fowl and hogs The house is invariably placed close to the road It is ordinarily square in ground plan, two stories in height, and capped with a mansard-like roof The barn is set back in such a position as to give easy access to both the fields and the farmyard Outdoor ovens are the rule, they are placed within easy reach of the woodshed and the back of the house Other structures follow no particular plan of arrangement Many farmers have hay barns located near the midpoint of the farm strip, but otherwise no buildings appear away from the farmstead Wood, usually unpainted, is the common material of construction (Pl LXXI, Fig 2)

The persons occupying the farmstead, with their French tongue and ancient customs, give the region a distinctly Old World complexion familiar to all who have traveled in French Canada The names of the villages and towns reflect this condition directly, as do many other things, such as the operation of the spinning wheel in the processing of wool for the making of the famous French-Canadian homespun The life of the family is entwined with the land and the parish church, it may be said, without any intent of sacrilege, that their energies are devoted to their animals and crops for six days of the week and to the worship of God on the seventh During the summer the work is directed toward the production of animal and human food, together with the activities of dairying and the transportation of milk to the local cheese-and-butter factory With the advent of winter the fields are deserted, but the other activities go on without interruption In spite of the hardships of the severe winters, it is a calm, steady, perhaps enviable, existence, little interfered with by the present world economic depression and its attendant cataclysms

Crop production is centered on feed for animals, chiefly dairy cattle The importance of hay and pasture in the agricultural

economy warrants the inclusion of the area in the Forest and Hay Region of North America, although in many respects, such as the export of cheese, it takes on the aspect of an outlier of the Hay and Dairying Region [27] Roughly two thirds of each farm is devoted to the production of mixed hays and to pasture, the remainder to oats, wheat, and barley chiefly, but in lesser amounts to potatoes, soup peas, buckwheat, turnips, and gardens It will be noted that the crops are of the hardy type — an obeisance to the dictates of a climate which allows on the average a growing season of not much over three months

In the sand and swamp portions there are relatively few farms, for reasons already noted Farm abandonment appears in these areas, partly as a reflection of soil and drainage conditions, but also because of a longer-continuing isolation and the recent raising of the lake level This abandonment is noticeable in the Taillon Peninsula, along the road east of Peribonca, and in the vicinity of St Méthode In spite of this, farm abandonment is not areally conspicuous, partly for the reason that the amount of land in farms in these portions was never very large The higher parts of the sandy terraces support occasional farms, often isolated from one another by spruce swamps and burned-over jack-pine plains This is especially true along the roads west and north of Dolbeau, where recently, as a result of governmental inducements, new and pioneer-like farms are being established (Pl LXX, Fig 1) It remains to be seen what modern methods, coupled with encouragement of a material nature by the government, can do with these lands

Regardless of the location of the farm the domestic animals constitute the hub of the rural economy Well-established farms, in the clay areas chiefly, have dairy cattle, horses, sheep, hogs, chickens, and ducks The numbers vary from farm to farm, but it is not uncommon for one to have fifteen or twenty dairy cattle

Most of the products of the farm are consumed in the plain However, great quantities of cheese are shipped to Montreal, along with lesser amounts of butter, beef, mutton, and pork On a rising market grains and hay may be shipped to Quebec and Montreal Hay, grains, and potatoes are sent to the "shanties" (lumber camps) in the upland during the winter season

[27] Baker, O E, "Agricultural Regions of North America," *Econ Geog*, 2 459–493 1926

Other phenomena directly related to the road and at the same time dependent on agriculture are the villages and some of the towns These features are numerous along the roads of the plain, but the upland supports very few (Map 9) In the lowland they are concentrated on the clays, although they do occur in the sand and swamp country Practically all are located at road crossings or intersections, a few are found at the crossings of the larger rivers (Map 12)

The village patterns conform very closely to the line of the highway, so closely, in fact, that they strongly resemble *Strassendörfer* (Pl LXXI, Fig 3, Pl LXXIII, Fig 2, Pl LXXIV, Fig 2)[23] These small concentrations of people depend entirely on the adjacent farms for their existence The dwellings are frame buildings, placed very close together, and front directly on the street itself The majority of the village dwellers have their own farms, which extend in strips back of their homes (Pl LXXIV, Fig 2) Furthermore, it is very difficult to ascertain, as one travels the roadway, exactly where the village terminates and the more open farming country begins Each village is dominated by the spire (or spires) of the parish church, actually this is the first thing one sees on approaching

There are some villages which illustrate a slight departure from the pattern described They differ in that they possess short offshoots from the main street, as where a road junction or a turn occurs The village of St Cœur de Marie shows this modified form (Pl LXXV, Fig 1) In cases of this sort the village takes on a T-shape when the offshoot is from the center, or an elbow shape when it has spread around a right-angle turn, as illustrated by Honfleur Two villages are distinctly irregular in pattern This is true of the village of Mistassini, where the highway ignores the survey lines in its attempt to cross the river Mistassini and its tributary the Mistassibi, and of the little settlement of Val Jalbert, the road in Val Jalbert makes a small bend away from the lake in order to cross the lower rapids of the Ouiatchouan

The towns of the lowland are of two kinds first, those that are dependent on agriculture, second, those that exist because of industrial enterprises The latter will be discussed subsequently, in a consideration of the nonagricultural forms associated with the road

[23] This is true of St Bruno, St Gédéon, Ste Croix, Chambord, St Prime, N D de la Doré, St Méthode, Normandin, Albanel, Ste Jeanne d'Arc, St Augustin, L'Ascension, and St Henri de Taillon

The former are but larger expressions of the villages — villages which have taken on further functions and have, as a consequence, grown in size and complexity of pattern Towns of this latter sort are Hébertville, Roberval, St Félicien, and St Jerôme

Hébertville possesses an irregular pattern, with tendencies toward rectangularity (Pl LXXV, Fig 2) The major portion of the town lies on the right bank of the Aulnets (Aulnais) at the junction of the Lake Kenogami–Lake St Jean road and the highway which leads south into the upland The town is centered functionally about a post office, a few general stores, and the church Roberval is situated on the lake shore between the water's edge and the railroad (Pl LXXII, Fig 2) It is oriented to the main street, which parallels the lake, and from this street other short thoroughfares extend at right angles There are also a few streets of varying length which are subparallel to the main artery Roberval is dominantly commercial, but the normal school, courthouse, and two churches are illustrative of other functions St Félicien is spread along a street which parallels the right bank of the Ashuapmouchouan, with some close building following a road to the southwest, for about a block, to the railroad station Like Roberval, it is tucked in between the water and the railroad Its function is commercial, although the magnificent church indicates a religious importance (Pl LXVIII, Fig 1) St Jerôme is similar to Roberval in function, but its pattern is quite different It occurs where a road following the lake shore meets at an oblique angle a road from the southwest Because of this the town assumes the shape of a Y

As may be seen from the airplane photographs, these towns grade into the surrounding fields, which lend to the settlements an atmosphere that one immediately associates with the countryside

Nonagricultural forms associated with the road — The industrial establishments associated with the road are secondary throughout the lowland to those of agriculture They comprise a major hydroelectric development, pulp and newsprint mills, cheese factories, small sawmills, blueberry canneries, and quarries Only the first three are of prime importance

At Isle Maligne, on the Grande Décharge, is a hydroelectric plant, one of the major plants of its kind in Canada (Pl LXXIV, Fig 1),[29] which is at present developing 540,000 H P In connection with

in Saguenay and Lake St John District, pp 10 11

this plant occur the dams and barrages which were mentioned above in the discussion of the stabilization of the lake level Power from this place is sent by transmission line to the mills at Dolbeau and across the Laurentians to Quebec The abundance of power at Isle Maligne has practically crowded out small electric plants elsewhere in the plain The railroad extension to the Décharges owes its existence to this Isle Maligne development Located near the plant are the homes of the employees, the officers and foremen live on the north bank, and the other workmen are quartered in straight lines of company houses on the south bank

The pulp and newsprint mills, and with them the mill towns, are located at Riverbend, Dolbeau, and Desbiens Riverbend (geographically a part of St Joseph d'Alma) lies on the north bank of the Petite Décharge (Pl LXXIV, Fig 1) It is a small settlement with an irregular, "American" plan of streets whose sides are flanked by homes of the bungalow type Adjacent, to the west, are the large buildings of the mill and the mammoth piles of pulpwood bolts The plan of Dolbeau is rectangular, in such a manner that the town is composed of square blocks Zoning plans have been adopted, so that there is a distinct business section and an equally distinct residential district It resembles in form, buildings, and other things the modern company towns of the United States so much so that it seems a cultural interloper which has somehow gained admittance to the French-Canadian circles of the region The mill at Dolbeau was in no small way a factor in the extension of the railroad from St Félicien to the Mistassini by 1926, and is also the reason for the attempts to improve the main highway around the north side of the lake Desbiens, at the mouth of the Metabetchouan, retains its French atmosphere in spite of its industrial function It fronts on the main road and extends to the railroad in a simple block pattern

Pulp wood, to feed the mills of these towns, is derived from the forests of the upland The newsprint produced is shipped out by rail to Quebec, or to the head of navigation on the Saguenay and thence to the outside world by boat

The town of St Joseph d'Alma (including Riverbend) is a reflection of both agricultural and industrial activities It serves the mill and the farm, in addition to the church It is famous throughout the region as a place possessing a regular motion-picture theater

Its pattern, irregular yet simple, is shown by the airplane photograph (Pl LXXIV, Fig 1)

Cheese-and-butter factories are scattered throughout the lowland, but are definitely concentrated in the clay areas These small establishments reflect the activities of the farm and consequently differ, in that manner, from the pulp mills and the power plant Situated as they are on the edge of the road, either in the towns and villages or here and there in the country, they will be found to have a distribution conforming to the road pattern

At Roberval, St Félicien, and St Henri de Taillon are small blueberry canneries Their operation is confined to a few weeks in midsummer, and their number, small size, and spasmodic operation relegate them to an insignificant place in the areal scene

There are numerous small sawmills located in, or adjacent to, the towns and villages, at places where small falls (or the damming of a stream along the side of the road) provide power for the making of laths, shingles, and rough boards Their meager production is consumed locally

This general treatment of the nonagricultural forms related to the road may be concluded with the mention of two quarries One, a shale quarry, lying just to the north of Roberval on the road to Pte Bleue, furnishes material for road surfacing, the other, northwest of Roberval on the St Prime road, provides a handsome pink granite used in the construction of churches and other public buildings in the adjacent portion of the lowland Obviously, then, to judge from the foregoing discussion, it is agriculture, rather than industry, that gives character to the settled parts of the Lake St Jean lowland

The Distribution of Population

A KEY TO THE LANDSCAPE OF THE LAKE ST JEAN LOWLAND

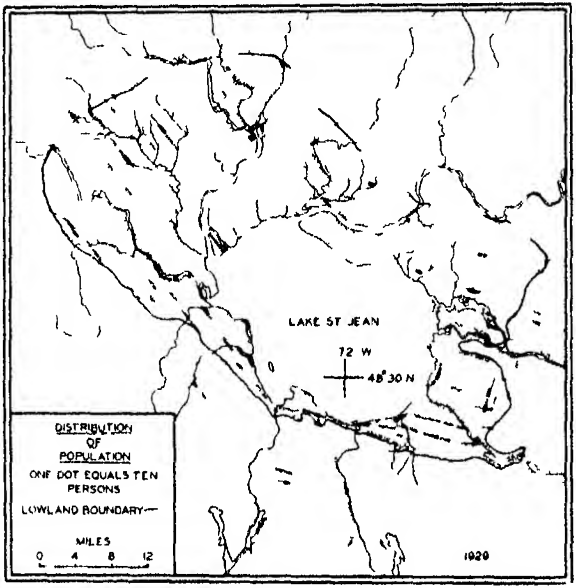
The agricultural and industrial forms which are distributed in relation to the arteries of travel owe their existence, as do the arteries themselves, to the presence of man in the area It is he who has extended the highway and moved along it, establishing his farms and settlements where conditions were favorable It is he who has, at a few points, attached the industrial forms to the surface of the earth Just as important to the areal scene is the fact that he has avoided certain parts of the lowland, and has left the upland nearly in

its natural state In this sense, then, the distribution of man in the region is the key to the distribution of other forms, both natural and cultural

Its relation to other landscape features — When we turn to the details of the population distribution, certain correlations with factors already described begin to stand out The population is seen to be concentrated in the lowland at the expense of the plateau — a concomitant to contrasts in power of attraction between the glacially eroded upland and the thickly soiled lowland Within the lowland concentrations occur primarily on the areas of clay loam In the other portions conditions of drainage and soil are such as to retard any great settlement, although locally, as near Dolbeau and Mistassini, the presence of labor-demanding mills has aided families to take up farms, the head of the family works in the mill, or perhaps in the "shanties" in the winter season, and the other members of the family carry on the work of the farm Also, as noted, government inducement is bringing about a new, purely agricultural settlement in parts of the sandy lands

Its pattern of distribution — The population pattern of the lowland is rather extraordinary (Map 13) Because population follows the road, it is linear but, because it follows only roads which lie along range lines and avoids those along lot lines, it is discontinuous The result is straight lines of population (Pl LXVII, Fig 3, Pl LXXI, Figs 2–3, Pl LXXIII, Fig 2, Pl LXXIV, Fig 2) To clarify this pattern a detailed map is presented (see the inset on Map 12) Part *B* of this map shows Canton Ashuapmouchouan with its roads, farm dwellings, and the settlements at St Prime and St Félicien The farmhouse is taken as the point of attachment of the population to the earth's surface The roads which extend northwest-southeast follow range lines (check with Map 11), the roads at right angles to these run along the lines of the lots Note that the farm dwellings hug the courses of the range-line roads but ignore the lot-line roads almost completely If this distribution is multiplied for the other cantons of the plain, the complete pattern shown on Map 13 is produced The exceptions to this straight-line distribution (see p 329, discussion of the occasional deviation of roads from survey lines) are also illustrated in the inset on Map 12 In part *B* the road north of St Prime is forced to curve with the edge of the water, hence a curve in the line of population follows

A further example of this is shown in part *A*, where the road between Roberval and Val Jalbert, bordering the lake shore, causes the population line to bend with it The rule and the minor exceptions



MAP 13 Based on field work, Royal Canadian Air Force photographs and data from *Statistiques municipales pour l'année civile 1929*, Bureau of Statistics, Quebec, and *L'Annuaire des Comtés de Chicoutimi et du Lac St-Jean*, Chicoutimi, 1929

thus exemplified in detail, when extended to the rest of the lowland portray the essentials of the population pattern

CONCLUSION

The attempt has been made to describe, by means of maps, photographs, diagrams, and text, the landscape of the Lake St Jean lowland in such a manner as to produce a concrete picture in the mind of the reader

This landscape has undergone a considerable change from the

time of its discovery in the seventeenth century to the present day This change has been accomplished chiefly by the French-Canadian farmer By neglecting certain areas and highly developing others he has produced the present patterns of the landscape complex The unifying element is the road, along which he moved and on which the circulation of the region still depends By settling directly at the roadside and extending his strip fields back from the road he has produced in the densely settled portions a continuous area of strip fields, through which the lines of population run as major threads in the warp and woof of the landscape pattern The lack of these threads in many of the sandy and swampy parts of the plain and in most of the surrounding upland denotes areas of little modification from the original natural condition

A PARTIAL LIST OF TREES AND SMALLER PLANTS IN THE LAKE ST JEAN AREA

This list is based on that of Dresser, *op cit* pp 17-18 Several additions have been made by the author The botanical names and most of the common names have been checked in *Gray's New Manual of Botany* Seventh Edition (American Book Company New York, 1908)

Pinus Banksiana, jack pine, northern scrub pine
Pinus resinosa, red pine
Pinus Strobus, white pine
Picea mariana, black spruce, bog spruce
Picea canadensis white spruce
Abies balsamea balsam fir, balsam
Thuya (Thuja) occidentalis, white cedar, common cedar
Larix laricina, tamarack, black larch, American larch
Populus tremuloides, poplar, trembling aspen American aspen
Populus balsamifera, poplar, balsam poplar tacamahac
Betula papyrifera, white birch, paper birch
Betula lutea, yellow birch
Betula pumila, swamp birch low birch
Betula glandulosa, dwarf birch
Acer spicatum, mountain maple
Acer negundo, box elder, Manitoba maple, ash leafed maple
Acer pennsylvanicum, striped maple, moosewood
Acer saccharum, sugar maple, rock maple
Acer rubrum, swamp maple, red maple
Salix nigra, black willow
Salix lucida, shining willow
Salix rostrata, common willow
Salix discolor, glaucous willow
Salix candida, sage willow hoary willow
Salix cordata, willow, no other common name

Salix petiolaris, willow, no other common name
Prunus pennsylvanica, pin cherry, fire cherry, bird cherry
Prunus virginiana, choke cherry, black cherry
Prunus pumila, sand cherry
Fraxinus pennsylvanica, red ash
Fraxinus pennsylvanica variety lanceolota, green ash
Fraxinus nigra, black ash
Ulmus americana, white elm, American elm
Ulmus fulva, slippery elm, red elm
Pyrus americana, mountain ash
Alnus mollis, downy green alder
Alnus incana, speckled alder, hoary alder
Cornus canadensis, dogwood, bunchberry, dwarf cornel
Cornus suecica, dogwood, no other common name
Cornus circinata, dogwood, round-leafed dogwood
Cornus sericea kinnikinnik, silky cornel, dogwood
Cornus stolonifera, red-osier dogwood, dogwood
Sambucus canadensis, common elder
Sambucus racemosa, red-berried elder
Amelanchier canadensis, service berry, shad bush
Taxus canadensis, American yew, ground hemlock
Rhamnus alnifolia, buckthorn
Viburnum Opulus, arrow-wood, high-bush cranberry, red berry
Viburnum pauciflorum, squashberry
Corylus americana, hazelnut
Spiraea salicifolia, meadow sweet
Myrica Gale, sweet gale
Symplocarpus foetidus, skunk cabbage
Gaylussacia dumosa, dwarf huckleberry
Gaylussacia baccata, black huckleberry
Vaccinium pennsylvanicum, low sweet blueberry
Vaccinium canadense, sour-top, velvet-leaf blueberry
Aster lateriflorus, aster
Cryptogramma Stelleri, rock brake
Ledum dilatatum, Labrador tea
Chamaedaphne calyculata, leather leaf
Sphagnum, many species, bog mosses
Cladonia rangiferina, reindeer moss

UNIVERSITY OF MICHIGAN

CHIEF REFERENCE MAPS USED IN STUDYING THE REGION

1 Carte Régionale du Lac St-Jean, Comprenant les Cantons Arpentés, Département de Colonisation, des Mines, et des Pêcheries, Quebec, 1928, 1929

2 Roberval Sheet, Sheet 34, Standard Topographical Series, Natural Resources Intelligence Service Dept Int , Ottawa, 1929 (not contoured)

3 Map of Saguenay Division, Price Brothers & Company, Ltd , Chicoutimi, 1929

4 Resource and Railroad Map part of Quebec Province, Natural Resources Intelligence Service Dept Int , Ottawa n d

5 The Counties of Chicoutimi and Lake St John, Province of Quebec, J F Grenon, Chicoutimi, 1928

6 Railway Map of Southeastern Canada, National Development Bureau, Dept Int , Ottawa, 1930

7 Automobile Roads between Canada and the United States (Atlantic Sheet), Natural Resources Intelligence Service, Dept Int , Ottawa 1930

8 Canoe Routes from L St John to L Mistassini, Natural Resources Intelligence Service, Ottawa, n d

9 Carte Routière et Touristique de Québec Province, Ministre de la Voirie, Quebec, 1932

10 Roberval, Lake St John County, Quebec, Map 184A, Geological Survey of Canada, Ottawa, 1916 (not contoured)

PLATES LXVII LXXV

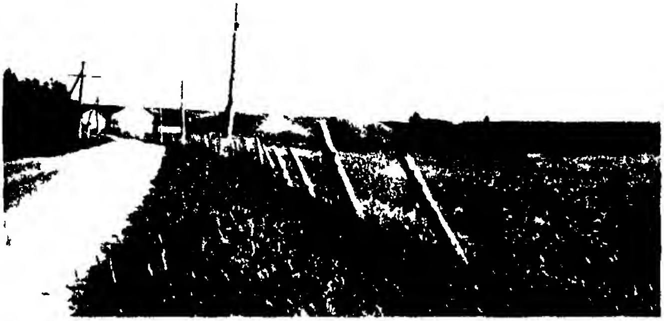


FIG. 1. Edge of second terrace just south of Roberval. Note the gullying

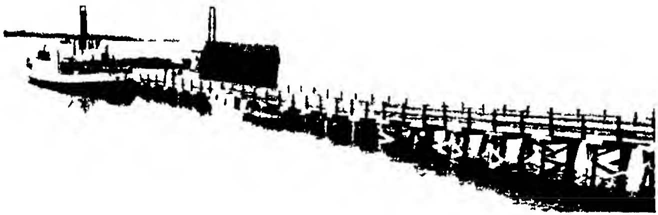


FIG. 2. The lower part of the Peribonca River at the village of Peribonca. Swampy Taillon peninsula in background. Boat and lumber barge just arrived from Roberval.

FIG. 3. Northwest view from the crest of the Cote St Prime. Note the line of buildings along the road in the central background.

PLATE LXVIII

FIG. 1. Southwest view across the Ashuapmouchouan River to St. Felicien. Upland in background.

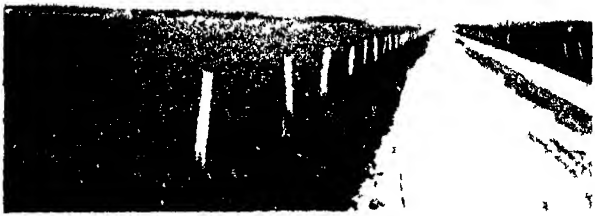


FIG. 2. The plain and upland east of St. Bruno along the main road to Chicoutimi.

XIX

Fig. 1. The lower rapids of the Peribonca River from the road bridge just west of Honfleur.

Fig. 2. The lower Metabetchouan River covered with pulpwood and the mill at Desbiens.

Fig. 1. New farm in the sand and swamp country along the main road west of Dolbeau

Fig. 2. Spruce swamp along the main road between Dolbeau and Albanel

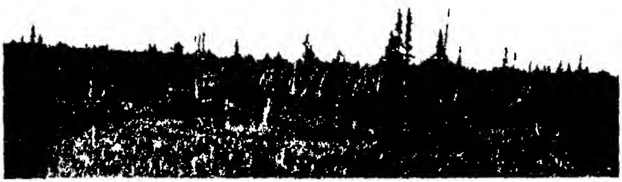


Fig. 3. Tamarack swamp east of Albanel along the main road

PLATE LXXI

Fig. 1. Newly burned jack pine plain just west of Dolbeau along the main road

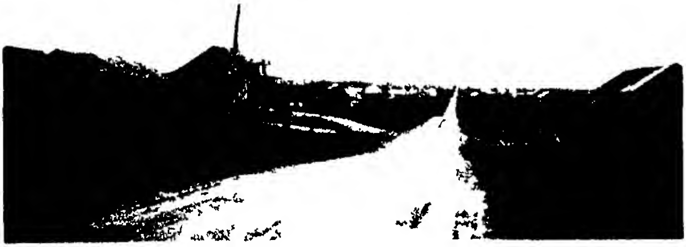


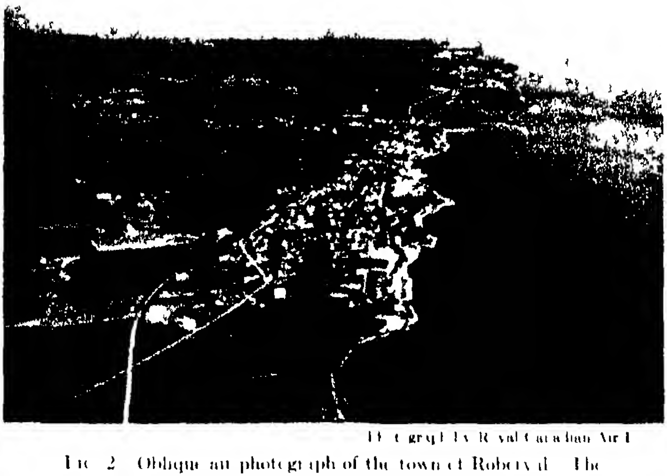
Fig. 2. Settlement along the range line road just south of

Fig. 3. View east along the main road (on lot line) to the of Albanel (on range line)

PLATE LXXII

Photograph by Royal Canadian Air Force

Fig. 1. Vertical air photograph of the rock outcrop area just west of St. Henri de Taillon.



Photograph by Royal Canadian Air Force

Fig. 2. Oblique air photograph of the town of Roberval. The wooded area is the Côte St. [illegible]

PLATE LXXIII

Photograph by Royal Canadian Air Force

Fig. 1. Oblique air photograph of the lowland and upland junction at Ouiatchouan Falls. View south from Val Jalbert. The mill and the village at the base of the falls are abandoned.

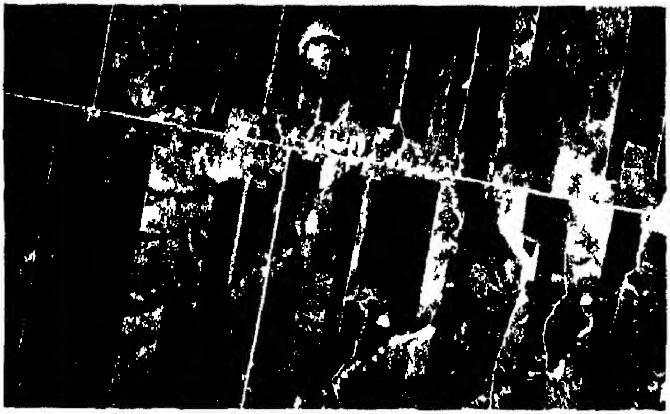
Photograph by Royal Canadian Air Force

Fig. 2. Oblique air photograph showing St. Gédéon, part of the eastern plain and the upland. Note the population lines and the strip field.

PLATE LXXIV

Photograph by Royal Canadian Air Force

FIG. 1. Oblique air photograph of St. Joseph d'Alma and Riverbend. Petite Décharge in foreground, Grande Décharge in background, pulp mill on outskirts of Riverbend, and power plant in extreme right of background.



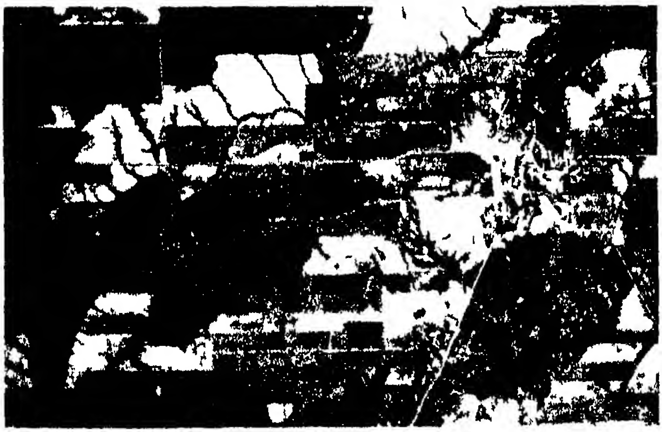
Photograph by Royal Canadian Air Force

FIG. 2. Vertical air photograph of the village and the vicinity of St. Bruno. Note the strip fields and the settlement along the north-south road (range line).

PLATE LXXV

Photograph by Royal Canadian Air Force

FIG. 1. Vertical air photograph of the village of St. Cœur de Marie. The water is part of the Grande Décharge.



Photograph by Royal Canadian Air Force

FIG. 2. Vertical air photograph of Hebertville and environs.

THE BLACK HILLS OF SOUTH DAKOTA AND WYOMING *

OTTO F GUTHE

INTRODUCTION

LYING more than one hundred miles east of the Rocky Mountain ranges the Black Hills rise from the gently rolling surface of the Northern Great Plains as an isolated mass of forested hills or low mountains (Map 14)[1] Distinct from their surroundings, the Hills have an insular quality which gives them an easily recognized regional unity Basic to this unity is the relief of the area High plateaus and peaks rise four thousand feet above the surface of the plains (Map 15 A) Their slopes support dense stands of pine, which, in contrast to the adjoining steppes, reflect the greater precipitation and more moderate temperatures of the higher elevations[2] The insularity of the area is enhanced by the character and arrangement of occupance forms Mining, ranching, lumbering, and recreation have combined to produce a distinctive cultural impress within the region

The regional design of the Black Hills is composed of gross features which emerge from the blending of an intricate detail The concentric arrangement of rock structure and surface features around the core of the eroded dome is the basis for the development of the major outlines of the region (Map 15 B), and the radial drainage pattern of consequent streams forms the skeleton for much of the detail of the regional scene (Map 16 B) The correspondence of the various elements of the landscape of this area with these major and minor lineaments can be brought out only by analysis

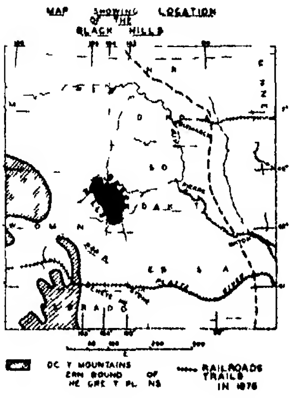
* The field work for this study was carried on during the summers of 1930, 1931, and 1932

[1] The Black Hills lie surrounded by the unglaciated Missouri Plateau section of the Great Plains province of the Interior Plains of the United States See Fenneman, N M, *Physiography of Western United States* (New York, 1931), map

[2] The Black Hills lie near the interior eastern edge of the BSk climatic region Some stations within the Hills have Dfb conditions See Köppen, W, *Grundriss der Klimakunde* (Berlin, 1931) pp 128–129

The Physical Background

The physical background upon which the forms of occupance within the Black Hills have been impressed may be resolved into its significant component parts the surface features, the drainage, the soil, the native vegetation, and the climatic characteristics By close examination of the maps which accompany the text the correspondence of the various patterns of the physical background should become strikingly evident



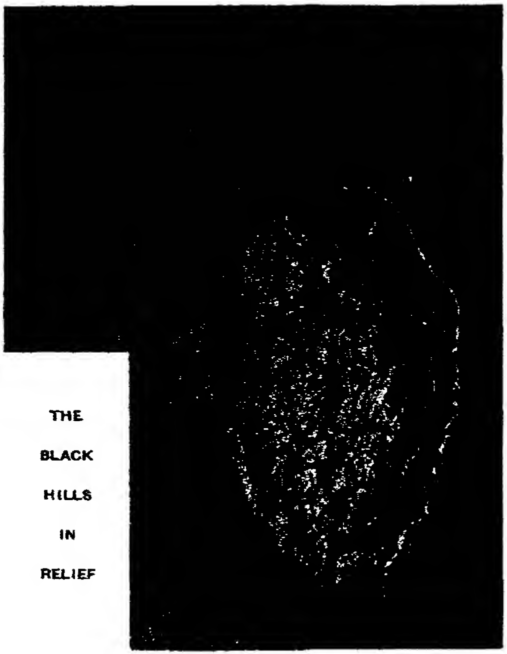
Map 14

Surface Features and Drainage

Geologically, the Black Hills are of a dome structure The main uplift is flattish on top, steeply sloping to the east, but dipping gently to the west (Fig 6) Its elliptical outline is accentuated by a secondary doming in the northwest Mature erosion of the main uplift has exposed a crystalline core characteristic of such structures (Map 15 B) Limestone strata partly mask the more elevated portion of the dome, and differential erosion of steeply dipping strata has formed a characteristic cuesta inclosing an inner lowland (Fig 6, Map 15 B) The radial drainage pattern has resulted in the orientation of minor features at right angles to the gross features Because of this great diversity of surface configuration it is possible to recognize several distinct divisions

The Interior Basin

The rugged surface of the Interior Basin, which has in some places a maximum relief of about a thousand feet, lies slightly east of the axis of the main dome of the Black Hills (Maps 15 A, 16 A, Fig 6) This basin corresponds in areal extent with the exposed crystalline core, its maximum length is some 60 miles, and its width



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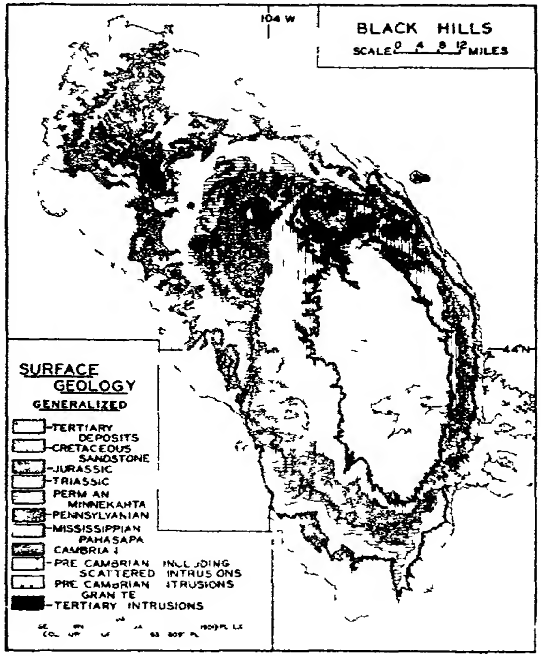


B

MAP 15

A From a drawing by J H Renshawe and O A Ljungstedt *Central Black Hills Folio* U S *Geol. Surv*, *Geol Folio 219*, p 1 1925

in no place exceeds 24 miles (Map 15 B) Three distinct types of surface configuration may be recognized The first is a surface of high relief, underlain by a complex structure of granite, pegmatite dykes, and quartzitic schists Granitic knobs and pinnacles dominate the scene, with their bare slopes rising almost perpendicularly from narrow ravines (Map 16 A)[3] This type of surface lies in the southeastern part of the Basin and culminates in Harney Peak,

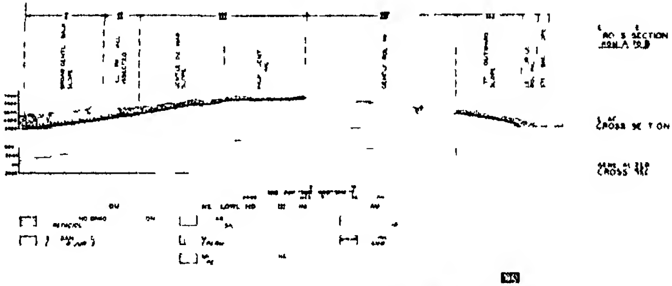


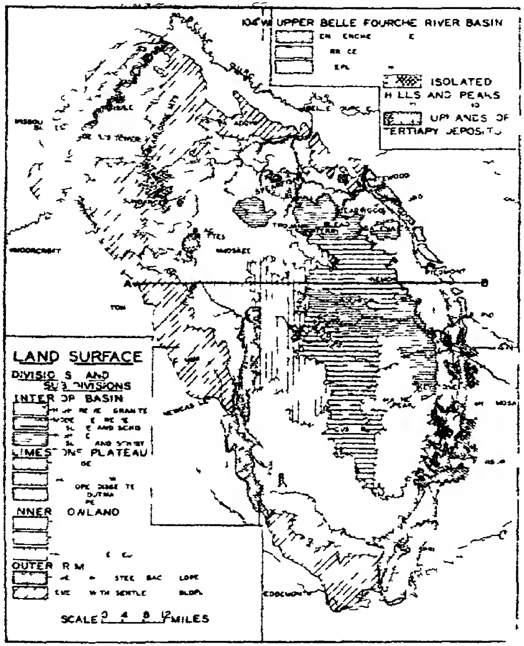
Fig 6 See Map 16 A for the location of this cross-section The exact cross-section is based on data from the U S Geol folios 127 and 219 The generalized cross-section is simplified by the omission of noncharacteristic forms and some of the deeper valleys

which has an elevation of 7,240 feet (Pl LXXVI, Fig 1) The second, a surface of slight relief, underlain by weak slates and schists and characterized by mature ridges and broad, shallow, mature valleys, is found where the more active streams have not yet succeeded in cutting back into the surface formed during an earlier erosion cycle (Map 16 A, Pl LXXVI, Fig 2)[4] The third, adjoining Rapid Creek, Whitewood Creek, and their tributaries, is a surface of high relief, also underlain by weak rocks, but deeply cut by vigorous youthful streams High on the valley sides are shoulders which are remnants of the earlier cycle (Map 16 A)[5] In general, the drainage lines cross at right angles to the axis of the Basin (Map 16 B)

[3] Hovey, E C, "Erosion Forms in the Harney Peak District," *Bull Geol Soc Am*, 11 582 1900

[4] Fillman, I, "The Cenezoic History of the Northern Black Hills," *Studies in Nat Hist*, *University of Iowa Studies*, p 23 1929 See also Fenneman, *op cit*, p 85

[5] Mansfield, G R, "Post-Pleistocene Drainage Modifications in the Black Hills and Big Horn Mountains," *Bull Harvard Coll Mus Comp Zool*, 49, No 3 58-87 1906



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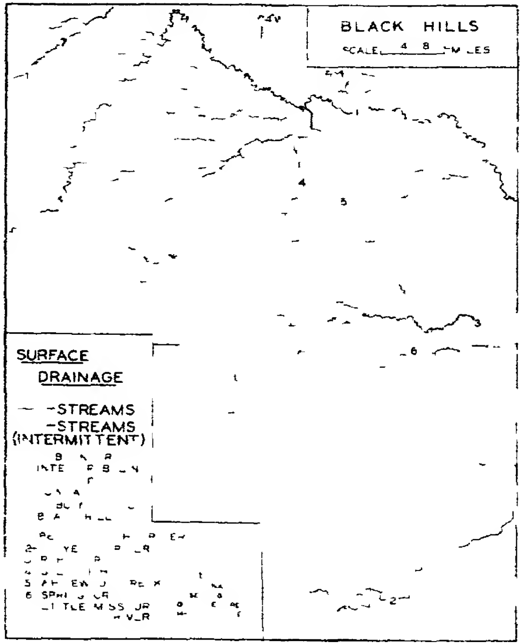


B

Map 16

A. Field data were compiled on maps of the scale 1 125 000
B Data compiled from U S Geol Surv topographic maps of the area The dates of preparation of the individual quadrangles vary greatly, so that there may be some slight error in representing the intermittent character of streams

The Limestone Plateau

Encircling and rising in places above all but the highest peaks of the Interior Basin, the Limestone Plateau presents a bold infacing escarpment averaging five hundred feet in height The surface of the Plateau is not level, but slopes at first gently, then more steeply, toward the surrounding inner lowland (Maps 15 A, 16 A, Fig 6) It is deeply dissected in its narrower parts by the streams which radiate from the center of the dome Beveling of Paleozoic rocks has produced a banding of outcrops which may be seen as one passes from the Basin directly across the Plateau A broad stretch of Pahasapa limestone is followed by an equally wide band of sandstone, but on the outer edge of the Plateau is the outcropping of resistant Minnekahta limestone, which forms a definite, although subdued, cuesta (Map 15 B)[6] To the west of the Interior Basin the Plateau has a gently rolling surface related to the cycle of erosion to which reference has already been made (Map 16 A)[7] Elsewhere, although the older surface may still be seen on the flattish interfluves, deep gorges with vertical walls, in many places six hundred feet high, have given to the surface a very rugged appearance (Pl LXXVII, Fig 1) Where the dip is steep the outer edge is well marked by the cuesta of Minnekahta limestone, which is a conspicuous feature " the outflowing streams invariably cut through it a V-shaped gateway, making in the interstream spaces crescent-shaped scarps of the 30-foot limestone over the soft red sandstone that underlies it The outer slope of the jointed limestone is usually washed bare and on the inner side of the Red Valley [Inner Lowland] forms what has been aptly called a tessellated pavement" (Map 16, A–B)[8]

The Inner Lowland[9]

An outcropping of weak Triassic red shale has been eroded to form the Inner Lowland[10] which surrounds the Limestone Plateau

[6] The sedimentary rocks outcropping in the Limestone Plateau range from the Upper Cambrian through the Permian Series The Pahasapa limestone is of Mississippian age The sandstone beds are Pennsylvanian, whereas the Minnekahta limestone is of Permian (?) age [7] Fillman, *op cit*, p 21

[8] Jaggar, T A, Jr, *Economic Resources of the Northern Black Hills*, Part I — General Geology, *U S Geol Surv*, *Prof Paper 26*, pp 16–17 1904

[9] This Lowland was called the "Race Course" or "Raceway" by the Indians

and is given a distinct outer boundary by the infacing escarpment of a prominent cuesta (Maps 15, A B, 16 A, Fig 6) This Lowland is interrupted at only one point, in the southeastern section of the Hills, by Tertiary uplands which extend from the Plateau on to the plains as uneroded remnants of extensive deposition (Map 16 A) In width the Lowland varies from less than one mile in constricted portions to more than ten miles near Sundance The major streams issue forth from the canyons of the Limestone Plateau and flow directly across the Lowland, escaping to the plains through water gaps in the cuesta (Map 16 B) As a result the floor of the Lowland is not flat, but is made up of a series of drainage divides, which are partly dissected by subsequent streams and separated by the broad alluvial flats of the consequent drainage lines Three types of surface may be noted within the Lowland The first is the level land, including the alluvial flats and a few extensive terraces some fifty feet above these flats (Map 16 A, Pl LXXVII, Fig 2) The second is composed of the hilly interfluve areas, surmounted in the northern portions of the Lowland by many flat-topped remnants of high terraces (Map 16 A, Pl LXXVII, Fig 2) The third, consisting of several areas of highly dissected land, gives a typical badland surface (Map 16 A)

The Outer Rim

A prominent cuesta, which rises conspicuously from the adjoining plains, forms the Outer Rim of the Hills (Map 15 A) It is underlain by resistant sandstone rock of Cretaceous age (Map 15 B) [11] and

of the region, but was termed the "Red Valley" by geologists Geographically the latter term is unsatisfactory because large areas within the Lowland do not exhibit red soil or red shale outcrops Portions of its inner edge are underlain by limestone, and some of its outer edges are formed on Jurassic beds in which the red color is lacking

[10] See Richardson, G B, "The Upper Red Beds of the Black Hills," *Journ Geol*, 11 365–393 1903

[11] The resistant strata of sandstone which form the cliffs and upper surfaces of the Outer Rim are of Lower and Upper Cretaceous age and are the same beds that are exposed as hogbacks along the Rocky Mountain Front See Darton N H, "Comparison of the Black Hills, Big Horn Mountains and Rocky Mountain Front Range," *Bull Geol Soc Am*, 15 379–448 1904 Usually the outer boundary of the Rim is along the contact between the Dakota sandstones and the shales underlying the plains, but exceptions occur For instance, the sandy beds of the Graneros formation (dominantly a shale) at times rise with sufficient prominence and are closely enough associated with the Hills in aspect to be included within the Outer Rim

presents an escarpment, in many places 600 feet in height, overlooking the Inner Lowland The steeply dipping strata on the eastern and southwestern sides of the dome have given this Rim a hogback appearance with narrow lateral extent (Map 16 A) Elsewhere the more gentle dip has allowed broad back slopes, in places deeply cut by streams, which have formed wide valleys between flat-topped interfluves (Map 16 A) Gullying by resequent streams is at some points pronounced, and the cuesta is broken into many segments by the water gaps of the major streams (Map 16, A–B) North of the Tertiary intrusion which formed the Warren Peaks the cuesta is aligned in relation to the secondary dome which occurs in the northwestern section of the Hills A 500-foot escarpment forms the western edge of the Bear-Lodge Mountains and overlooks the Upper Belle Fourche River Basin From here the cuesta dips to the east and merges with that portion aligned to the main mass of the Hills

Other divisions, not arranged concentrically with regard to the main dome structure, occur within the region and must be discussed

The Upper Belle Fourche River Basin

"The valley of the Belle Fourche has been eroded in the flanks of a broad uplift   In fact the rocks removed to form the valley hardly interrupt the gentle sweep of the skyline as one follows the profile of the land " [12] The present intrenched valley of the Belle Fourche with its low terraces is bounded on the east and west by high, dissected, terrace-like ridges, which are broken into flat-topped segments by the deep valleys of the streams tributary to the river Between these ridges and the escarpments of the Outer Rim east of the Basin is a zone of steeply sloping land, intermediate in elevation and dissected by deep youthful valleys (Map 16 A) The drainage of the Basin is characteristically dendritic, and the interfluves send out narrow fingers between the tributary valleys (Map 16 B)

Isolated hills and peaks formed by Tertiary intrusions

The isolated hills and peaks formed by Tertiary intrusions are localized in the northern Hills (Maps 15 B, 16 A) [13] They are,

[12] Russel, I C, "Igneous Intrusions in the Black Hills," *Journ Geol*, 4 34 1896

[13] Many of the intrusions are so minor or so far advanced in erosion that they blend into the general surface of their surroundings and are not treated in this division

apparently, all of laccolithic structure [14] In some the intrusive rock has become exposed by erosion, in others the sedimentary capping rocks still remain The dominating Warren Peaks, the Missouri Buttes, Devil's Tower, and the Black Buttes are included within this division

Uplands of Tertiary deposition

Remnants of Tertiary deposition cover small areas in many parts of the Hills, both in the older valleys and on the ridge tops The greatest area of such deposits, however, is in the southeastern portion of the Hills extending from the Interior Basin on to the Plains (Maps 15 B, 16 A) Tentacles of these sediments stretch into the Hills along the old drainage lines and occupy saddles which lead to the Interior Basin They reach their greatest breadth just outside the Limestone Plateau, where they form flat-topped ridges interrupting the continuity of the Inner Lowland

Drainage characteristics

The streams, which have introduced the detail into these divisions, gain in volume as they flow through broad, shallow valleys near their headwaters As they descend through deep gorges to the level of the Inner Lowland, much of the original flow seeps into porous sandstone rock, which forms an artesian reservoir for the surrounding plains Crossing to the Outer Rim, they reach the Plains through water gaps, but here, also, the sandstone strata underlying the Outer Rim greedily takes as much of the remaining flow as possible, so that many streams disappear from the surface The streams of the northern Hills are larger and more constant than those to the south Even the larger valleys in the south exhibit dry stream beds during several months of the year The Belle Fourche and the Cheyenne rivers encircle and seem to hold the Black Hills in their clasp, secure because of the extending tentacles which reach into the very heart of the region (Map 16 B)

The mold

The major lineaments of the surface, recognizable in the preceding divisions, form the gross features of the mold to which the broad

[14] See Jaggar, T A, Jr, and Howe, E, "The Laccoliths of the Black Hills," *U S Geol Surv*, *Twenty first Annual Report*, Part III 163-303 1901

distributions of the significant forms of the landscape of the Black Hills are shaped The drainage pattern, a more detailed part of the design of this mold, is the unifying bond for the areally less important, but nevertheless striking, details of the areal scene

OTHER ELEMENTS OF THE PHYSICAL BACKGROUND

The patterns of soil, native vegetation, and climate show a distinct tendency to conform to the design of the mold This correspondence is most striking in the case of soil, less so in respect to the native vegetation, and least noticeable, except for the broader aspects, in respect to climate

Soils

The distribution of the edaphic conditions is genetically related to the surface configuration and to the distribution of the significant features of the geognosy of the area Of greatest areal importance are the residual soils which are found on the interfluves These soils are arranged concentrically around the exposed core of the main uplift and, in detail, around minor domings within the region Being immature, they vary greatly in composition and texture, since they are a reflection of the underlying geologic materials [15] Where it is of sufficient depth, the soil derived from the crystalline and limestone rocks is highly productive That derived from the sandstone is of too coarse a texture and is too easily eroded to be widely cultivated The shale, especially that of the Inner Lowland, has weathered to a clayey loam, generally too compact to favor tillage It can be worked only under a closely restricted range of moisture conditions, so that crop yields on it vary greatly from year to year In the swales, where moisture is more reliable, cultivation is generally successful

Alluvial soils, forming narrow bands along most of the streams, broaden in lateral extent where the major streams cross the Inner Lowland They are distributed, therefore, in a radial fashion in accordance with the drainage pattern It is on these soils that agri-

[15] It must be kept in mind that "when the strata comprise alternating beds of different materials, such as shales and sandstones alternating with limestone, there are abrupt transitions in the resulting soils, which may differ widely in composition and agricultural capabilities in zones that lie side by side and are too narrow to map" See Darton, N H, *Central Black Hills Folio, U S Geol Surv*, *Geol Folio 219*, p 32 1925

cultural production reaches its greatest concentration, especially where irrigation can be practiced

The pattern of the native vegetation shows a close correlation with these distributions but also reflects in a more general way the varying aspects of climate

Native vegetation

The vegetation of the Black Hills is composed of elements which are now largely disjuncts, with the exception of the flora characteristic of the Great Plains [16] During earlier periods plants from the west, east, north, and south advanced into the Hills, and now remain associated together within the region, but separated from their respective areas of widespread occurrence [17]

The three major vegetational climaxes of the United States — grassland, scrub, and forest — present a very definite pattern within the Hills The Interior Basin is dominated by medium to dense stands of western yellow pine (*Pinus ponderosa scopulorum*) associations The higher portions of the Limestone Plateau are similarly covered (Map 17 A) Several types of breaks occur in this pine forest Some align themselves with the streams and follow the drainage patterns rather closely where the valleys are broad and shallow A zonation from willow and prairie grassland along the streams gives way to an aspen (*Populus tremuloides*) growth bordering the dense stands of pine on the ridge slopes (Pl LXXVI, Fig 2, Pl LXXVIII, Fig 1) Breaks of another type are locally extensive So-called upland prairies, such as the Reynolds Prairie, are grasslands of the mixed prairie association entirely surrounded by forest (Map 17 A) [18] A third type of break is seen in the large burns, which are a common sight in the interior (Map 17 A, Pl LXXVII, Fig 1) [19]

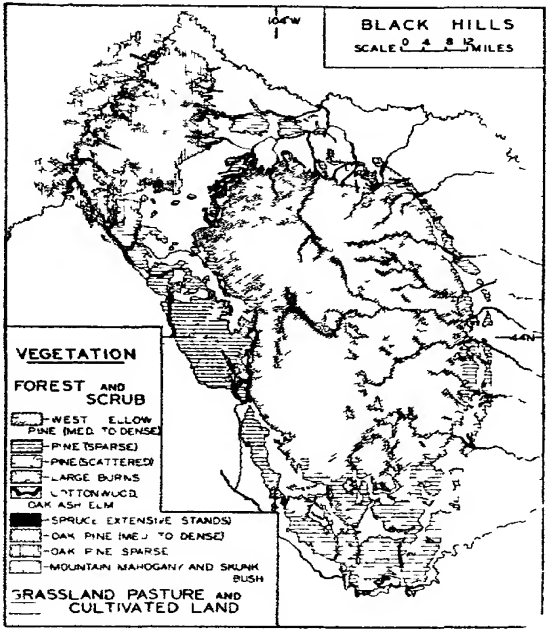
On the outer lower slopes of the Plateau bordering the Inner Lowland sparse stands of pine and scrub growth are characteristic The Inner Lowland itself is conspicuous because of its grasslands (Pl

[16] Shantz classifies the native vegetation of the surrounding plains within the Short Grass (plains grassland) division See Shantz, H L, and Zon, R, "Natural Vegetation," *Atlas of American Agriculture*, U S Dept of Agric Part I, Sec E, maps 1924

[17] McIntosh, A C, "A Botanical Survey of the Black Hills of South Dakota," *The Black Hills Engineer*, 19 198 1931

[18] *Ibid*, p 207

[19] Jenny, W P, and Newton, E M, *Report on the Geology of the Black Hills of Dakota, U S Geog and Geol Surv* (Washington, 1880), p 322



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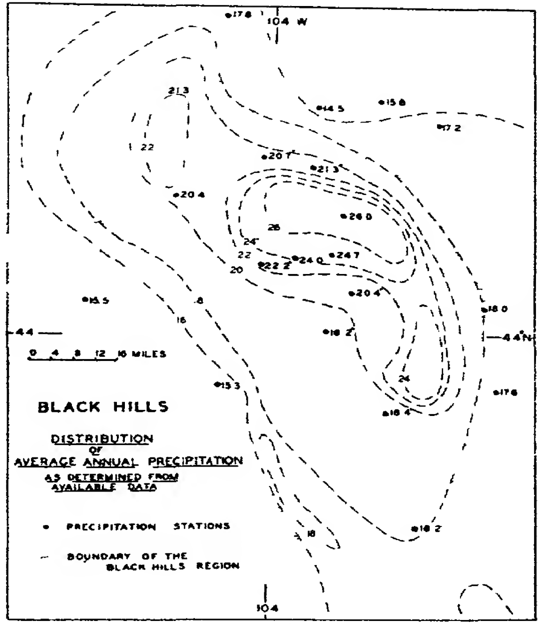


B

Map 17

A. The legend indicates dominants in associations which are conspicuous in the landscape. Differentiations are based on striking contrast in visual aspects. The distributions are generalized from field data placed on maps of the scale 1 : 125 000

B. Data compiled from *Climatological Data for the United States by Sections* (U. S. Department of Agriculture Weather Bureau) with the averag[e] determined through the year 1930 for most stations

LXXVII, Fig 2), but it is hemmed in by the scattered, gnarly stands of western yellow pine which cover the higher portions and the back slopes of the Outer Rim To the north bur oaks (*Quercus macrocarpa*) become codominant with the pine, especially in the Upper Belle Fourche River Basin (Map 17 A)

Characteristic transitions can be recognized on the valley floors as one proceeds from the plains toward the headwaters of the major streams First are seen the cottonwoods, which form narrow belts rising conspicuously above the steppe of the plains and of the Inner Lowland Many hardwoods, such as oak, ash, and elm, form dense stands at the entrances to the canyons cut in the Limestone Plateau In the more rugged portions of the Hills aspen and paper birch (*Betula papyrifera*) choke the narrow valleys, but grasslands and willows border the streams which meander through the broader valleys Near the headwaters of these streams spruce (*Picea canadensis*) covers the north-facing slopes and may extend down to the immediate stream bank (Map 17 A) The detail in the distribution of the vegetation corresponds, therefore, with the drainage pattern and its relation to the minor features The variations in soil characteristics, so closely related with surface, show marked relationships with vegetation distributions, especially along the boundaries between recognized associations The fine, deep soils and clays are usually devoid of tree growth, as in the Inner Lowland Sandy or rocky soils tend to support trees if climatic conditions allow, as on the slopes of the Outer Rim and the rocky lower slopes of the Limestone Plateau [20]

Climate

The general features of the climate of the Northern Great Plains show the Black Hills to be climatically distinct from the surrounding steppes Outside the Hills conditions are definitely semiarid, in the interior of the region humid conditions of equal distinctness are found Hence, the climate of the area may be characterized as a transitional zone through which more and more humid conditions are noted as the center of the Hills is approached

Over 75 per cent of the annual precipitation takes place during the growing season At Belle Fourche, the station having the least average annual rainfall for the surrounding area, the total precipi-

[20] Hayward, H E, "Studies of Plants in the Black Hills of South Dakota," *The Botanical Gazette*, 85 399–400 1928

tation is 14 54 inches The maximum recorded average annual precipitation, 25 98 inches, occurs at Lead (Table I) The general rainfall pattern, as indicated by isohyets of average annual rainfall, tends to present a roughly elliptical shape, although offset to the northeast A marked concentration is shown in the northeastern portion of the Hills (Map 17 B) The effect of this distribution is seen in the flow of streams as well as in the density of forest growth

Elevation and forest cover diminish the annual temperature range and the length of the growing season The ranchers and the National Forest Service recognize three zones The highest, lying between 6,000 and 7,000 feet, primarily upon the high Limestone Plateau west of the Interior Basin, has a three-month growing season, and agriculture is carried on with difficulty Only the hardier grains and timothy hay can be grown Most of the remainder of the upland area is included within the second zone, which lies between 4,500 and 6,000 feet Here the growing season is about four months long and allows the more successful cultivation of small grains and vegetables The third zone lies below 4,500 feet and extends on to the plains The growing season is at least four and one-half months long, and all common grains, vegetables, and even corn can be grown

Although a general correlation between vegetation and climatic distributions undoubtedly exists, in detail it seems to be largely overshadowed by variations in the edaphic conditions Great variability in precipitation from year to year, coupled with the short duration and the irregularity of weather observations at most of the widely spaced stations within the area (Table I), do not allow one to draw conclusions regarding the relationships of climate and vegetation

The physical background of the region, thus analyzed, was the setting which the incoming population of the Black Hills occupied and changed The patterns resulting from this occupance complete the areal scene

The Cultural Impress

The entrance of man into this area has brought modifications in the details of the regional design, but the gross features remain unchanged The first white settlers were attracted by the reports of gold, and before long placer and lode mining dominated the early

B

Climatic Data

Station	Length of record	Elevation (in feet)	Average annual precipitation *	Average annual temperature †	Average of three warmest months	Average of three coldest months
Lead	22	5 200	25 98	43 6	62 4	23 5
Spearfish	41–34‡	3,600	21 29	46 3	67 0	25 9
Sundance	25–22	4,750	20 44	40 9	63 5	19 7
Oelrichs	40–33	3 339	19 45	46 1	69 4	22 5
Hot Springs	27–22	3 505	18 17	46 7	69 0	24 2
Rapid City	43	3 251	17 98	46 1	68 3	24 2
Colony	17	3 500	17 84	46 1	69 1	20 9
Hermosa	32–26	3 278	17 58	45 8	67 9	24 2
Vale	23	2 765	17 24	45 0	68 6	20 6
Ardmore	21–17	3 557	16.82	44 5	68 7	19 7
Orman	25–24	2 920	15 64	46 1	69 6	21 8
Upton	13	4 242	15 52	42 4	67 0	16 5
Newcastle	22	4,317	15 33	45 7	69 5	23 2
Belle Fourche	22	3 020	14.54	44 9	67 7	21 6

* Precipitation in inches
† Temperatures in Fahrenheit
‡ The first number refers to the length of precipitation records the second to the length of temperature records

Data for all stations except Hermosa and Upton are from averages obtained from *Climatological Data for the United States by Sections* (U S Department of Agriculture, Weather Bureau) Vol 17 No 13 (1930) South Dakota Section, XXXV 50–52, Wyoming Section XXXIX 54–56 For Hermosa see *ibid* Vol 15 No 13 (1928) South Dakota Section XXXIII 50–52 for Upton see *ibid* Vol 14 No 13 (1927) Wyoming Section XXXVI 54–56

cultural scene On the heels of the miners came the ranchmen, followed almost immediately by the lumbermen, both groups eager to furnish the miners with supplies At first these modes of occupance were closely interdependent, but they have since expanded beyond their original restricted contacts More recently tourists have introduced recreation The widespread expansion of settlement characterizing the early years had proved much of the area unsuitable for ranching and mining, and abandonment of the poorer sites took place (Pl LXXVIII, Fig 2, Pl LXXIX, Fig 1), with a consequent concentration on the better areas

THE COURSE OF SETTLEMENT

The course of settlement of this region by white people covers only a brief span of some sixty years, but during this time several different modes of occupance have guided the settlement through successive periods of prosperity and decadence The great wave of immigration into the Hills began in the late fall of 1875 and the spring of 1876, with Custer, the original discovery location of gold, as the objective point At this time the population of the town was from 6,000 to 10,000 people [21] In the late spring of 1876 rich placer discoveries in Deadwood Gulch in the northern Hills emptied Custer of all but fourteen people Deadwood, the center of activity in the northern Hills, sprang into prominence Other mining camps experienced periods of hectic prosperity, but most of them are today abandoned or even obliterated The main routes by which supplies reached these early prospectors were northward across the plains from the railroad stations of Sydney and Cheyenne, or westward from Bismarck and Fort Pierre (Map 14) [22]

Soon after this rapid increase of mining within the interior of the Hills the spread of settlement was directed outward to the Inner Lowland and the skirting plains Ranching became an important activity with hay cultivation and grazing of livestock dominant, and with the mining towns serving as markets Some of the more important entrance towns to the Hills obtained their start at this time Rapid City, Spearfish, and Sturgis were established in 1876-77 (Map 16 A)

[21] Tallent, A D, *The Black Hills* (St Louis, 1899), 140-141

[22] Ayres, G V, "Early Transportation," *The Black Hills Engineer*, 18 12-18 1930

The population dependent upon ranching has shown fluctuations similar to those characteristic of all western South Dakota. Increases and decreases are related in time with variations in rainfall. In 1880 the population of the Black Hills and the closely adjoining plains was 16,726. The great boom period of settlement in the rest of South Dakota nearly coincided with the first years of expansion in the Hills — years of more than average rainfall. There followed a series of droughts from 1886 to 1897, and during this time Custer, Fall River, and Pennington counties, comprising a large part of the region, all experienced decreases in population. Well-established towns on the outskirts of the Hills showed similar decreases, as indicated by the accompanying table. Fluctuations in the mining population cannot be correlated with those of ranching areas, as is evidenced by the continued growth of Lead and Deadwood, supported by the booming mines of that period (Table II).

County	1900	1890	Town	1900	1890
Custer	2728	4891	Rapid City	1342	2128
Fall River	3547	4478	Hermosa	77	172
Pennington	5610	6540	Hot Springs	1319	1423
			Newcastle	756	1715
			Sundance	294	51[illegible]

The decline in population described for the outskirts of the Hills was followed during the next decade by a rapid increase. This growth was probably due in part to a series of "wet" years and in part to the increased development of railroad communication and the resulting breakdown of isolation. It is true that railroad connections with the Black Hills were established by 1891. Two lines, one from the south proceeding directly through the center of the Hills and one skirting the eastern edge of the region, reached Deadwood in that year (Map 18 A). Towns, such as Piedmont, Whitewood, and Newcastle (Map 18 A), were born with the advent of the railroads at those points. The great impetus for development came in 1907, however, when the Chicago and Northwestern and the Chicago, Minneapolis, and St. Paul entered Rapid City from the east (Map 18 A).[33] From this time on Rapid City was definitely the trade center of the Hills and the focal point for all traffic eastward (Pl. LXXIX, Fig. 2).

[33] See *Board of Railroad Commissioners, State of South Dakota*, Annual Reports beginning 1889.

TABLE 11

POPULATION STATISTICS

Counties

Year	Butte	Crook	Custer	Fall River	Lawrence	Meade	Pennington	Weston
1930	8,589	5,333	5 353	8,741	13,920	11,482	20,079	4,673
1920	6,819	5,524	3 907	6,985	13 029	9 367	12 720	4 631
1910	4,993	6,492	4,458	7,763	19,694	12 640	12 453	4 960
1900	2,907	3,137	2,728	3 547	17,897	4 907	5,610	3,203
1890	1,037	3,203	4 891	4 478	11 673	4 640	6 540	2 422
1880			995*		13,248†		2 244	

Towns

Year	Belle Fourche	Central City	Custer	Deadwood	Edgemont	Fairburn	Hermosa	Hill City	Hot Springs	Lead
1930	2,032	198	1 203	2 559	1 103	91	128		2 908	5 733
1920	1,616	199	595	2 403	1,254		74		1 697	5 013
1910	1,352	296	602	3 653	816		114	271	1 865	8,392
1900	451		599	3,498	479		77		1 319	6,210
1890			790	2,366			172	479	1,423	2 581
1880		1,008	271	3,777						1 437

Year	Moorcroft	Newcastle	Newell	Oelrichs	Osage	Rapid City	Spearfish	Sundance	Upton	Whitewood
1930	341	1,201	547	206	457	10,404	1,577	369	373	392
1920	420	1,003	414	176		5,777	1,254	328	306	339
1910	178	975		150		3 854	1 130	281	244	390
1900		756				1 342	1 166	294	246	311
1890		1 715		303		2 128	678	515		443
1880						292	170			

* Includes the present Fall River County † Includes portions of Butte, Meade and Pennington counties.

Data from *Census of the United States* Nos. 10–15, United States Department of Commerce, Bureau of the Census

The urban populations of the well-situated towns advanced during the decade from 1910 to 1920 (Table II), probably in part as a result of this better transportation and an increase in trade, but the rural population decreased The ranchers experienced three years of drought near the first of the decade and recognized the advantages of enlarged farms, the application of dry farming methods, and an increase of stock grazing [24] During the same period the mining centers of Lead and Deadwood showed marked declines, for many of the large mines of the area were closed down

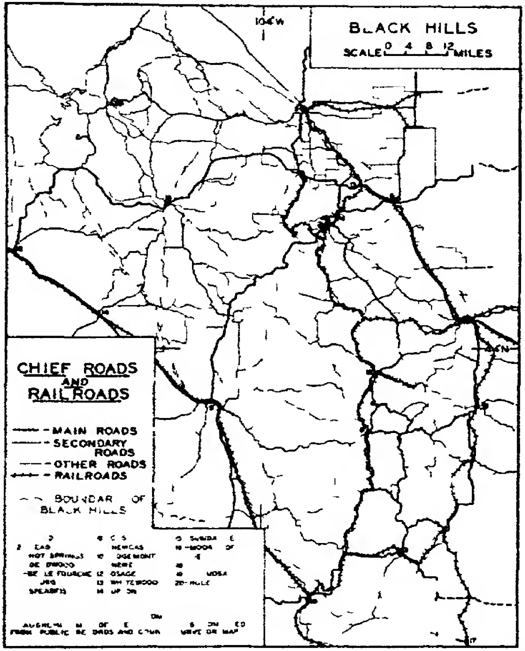
From 1920 to 1930 tourism assumed truly significant proportions, and nation-wide advertising, coupled with a series of "wet" years, attracted many to the Hills With the development and improvement of roads the population increased rapidly in both rural and urban areas (Table II)

THE PRESENT DISTRIBUTIONS OF PEOPLE AND ROADS

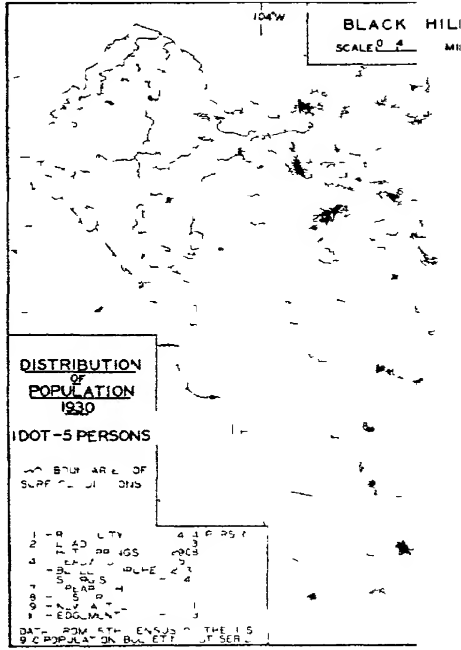
The present pattern of population distribution has emerged from the flow of these fluctuating numbers over and around the features of the physical background The larger population agglomerations are now at the chief commercial foci or at the mining centers Of the 42,000 inhabitants within the Black Hills 29,000 live in agglomerations (Table III) The remainder of the population is widely dispersed (Map 18 B) In some parts of the Hills many miles separate the individual homesteads, and the distance is magnified by the difficulties of communication The ultimate of this pattern of dispersal is the lone prospector living in his cabin in a secluded gully, or the solitary rancher who is content with his small plot of potatoes, a few head of cattle, and the lumber which his homesteaded land provides This dispersed population is united with the population nuclei by roads which converge on the focal points and present a loosely woven mesh covering the surface (Map 18 A) Main roads, carrying more than average traffic, are graded and usually surfaced These express the main arteries of travel, whereas secondary roads are traveled less frequently and are merely graded The pattern is complicated by other roads of lesser importance, which are ungraded and are used only by the more dispersed population

Within the Interior Basin the population has a total density of

[24] Visher, S S, "The Geography of South Dakota," *South Dak Geol and Nat Hist Surv* Bull 8 139–162 1918



A



B

Map 18

B Areas with no data available have very few people The placement of dots was controlled by field work general knowledge of the area, and close study of the U S Geol Surv topographic maps

TABLE III

Quantitative Analysis of Population Distribution

Data based on planimeter readings of the Black Hills region (approximate)

Division	Area (in square miles)	Total population	Disseminated population	Disseminated density per square mile	Agglomerated population	Total density per square mile
Interior Basin	961.8	14,849	4,155	4.3	10,694	15.4
Limestone Plateau	1,521.2	2,277	2,230	1.5	47	1.5
Inner Lowland	661.0	20,537*	3,140	4.8	17,397*	31.1
Outer Rim	1,235.2	2,741†	1,540	1.2	1,201†	2.2
Upper Belle Fourche River Basin	377.1	1,550	1,450	3.8	100	4.1
Uplands of Tertiary deposition	50.8	75	75			
Isolated hills and peaks formed from Tertiary intrusions	59.3					
Total	4,866.4	42,029	12,590		29,439	

* Includes Rapid City † Includes Newcastle

Population data taken from maps compiled from statistics of the *Census of the United States*, No. 15, United States Department of Commerce, Bureau of the Census

15 4 per square mile, but outside the agglomerations the density per square mile is only 4 3 (Table III) There is a tendency toward concentration on the broad parks or in the narrow confines of deep valleys Mining clusters have grown up in striking contrast to their scantily populated surroundings (Map 18 B) Roads reach the Basin by direct routes across the encircling plateau, and most of them are aligned north-south within the division itself Generally speaking, they retain their routes within the valleys as much as possible, traversing the ridges only in order to reach adjoining valleys (Maps 16 A, 18 A)

On the other hand, the Limestone Plateau has a highly disseminated population, with a density of only 1 5 per square mile Large areas are too high for successful cultivation, and much of the Plateau is relatively inaccessible There is, however, a tendency toward concentration along the outer margin of the Plateau, where the slope is gentle and where the soil is derived from the Minnekahta limestone (Map 18 B) The alignment of roads is a reflection of their function of connecting the outskirts of the Hills with the population agglomerations of the Interior Basin

Within the Inner Lowland marked population clusters are found on or bordering the flat areas of alluvium or, in a few areas, on the lower terrace deposits which can be used for agriculture Small towns, foci for the surrounding ranchers, are located at points where the major streams cross the Lowland (Map 18 B) The predominance of an agglomerated population is shown by the fact that the total density per square mile is 31 1, whereas that of the dispersed population is only 4 8 per square mile Main roads, which almost encircle the Hills, confine themselves to the gently rolling plain, southeast and west of the region, but traverse the Inner Lowland to the northeast, north, and south, where extensions of the Hills would otherwise cause marked deflection from the east-west line of travel and where easy access from the east is obtained by way of the water gaps The road pattern, unlike that in the rest of the Hills, is rectangular at a few points within the Lowland (Maps 16 A, 18 A)

In contrast to the Inner Lowland the steeply sloping eastern portion of the Outer Rim is practically uninhabited, but to the west the broad valleys and flat-topped ridges are the sites of many ranches, which explain the population density of 2 2 per square mile (Map 18 B) The ranchers of this division are served by the small towns

of the Inner Lowland or by those on the adjoining plains Most of the chief roads cut transversally across the Outer Rim, following either the valleys or the ridge tops

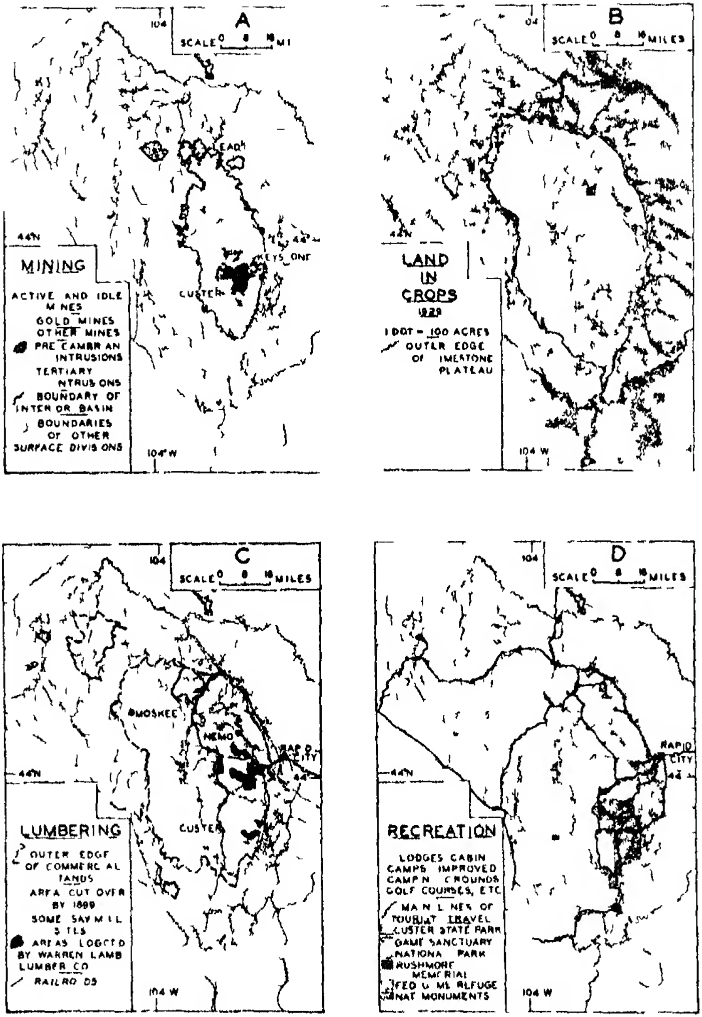
In the Upper Belle Fourche River Basin the majority of the ranches are in the valleys The focus of the area is Hulett (Map 18 B) It is toward this center that the roads converge Finally, on the Uplands of Tertiary deposition there are a few ranches where water is available and the soil suitable for agriculture

Beyond the outer margin of the Hills the scarcity of water and the character of the soil results in a concentration of habitations along the streams or near the water supply offered by artesian wells The marked concentration of the rural population east of the region may be correlated with the abundance of water descending from the Hills and with the existence of terrace deposits which cover the gumbo clay The effect of the Government irrigation project east of Belle Fourche is seen on the map of population distribution (Map 18 B) Rectangularity of road pattern on the plains is common, but a general convergence of routes toward the main entrance towns of the Black Hills is discernible (Map 18 A)

Concentration of agglomerations in the eastern portion of the region is associated with several facts it is here that the mines are located, water is abundant, the main tides of settlement advanced from the east and south, markets lie to the east, and railroads lead in that direction A striking correlation between the distribution of railroads and population centers is apparent Towns distant from the railroads are showing definite signs of retrogression, whereas Rapid City at the railroad focus of the region is the largest agglomeration of the Hills

THE MODES OF OCCUPANCE

Four modes of occupance have reacted on the regional scene mining, ranching, lumbering, and recreation Though there has been, as we have indicated, something of a succession of these modes in time, yet all of them survive and are still active in one part or another of the Hills Each group of people, with its individual mode of occupance and in accordance with its own necessities, has sought out and utilized quite different elements of the physical background One has made use of the rich ores, another, the plentiful supply of timber, another has brought about the settlement of areas favorable



MAP 19 For explanation of maps see bottom of opposite page

for agriculture, and still another has recently developed the utilization of recreational advantages offered by the Hills[25] Several distinct patterns result Each of these is a generalization of the distribution of the specific forms resulting from one mode of occupance Yet from the blending of all these patterns impressed upon the physical background emerge those qualities and characteristics which give individuality to the occupance of the region In other words, the unity of occupance within the region may be resolved into its component parts

Mining

Mining is concentrated within the Interior Basin, where mineralized zones occur in close association with igneous rock which has been intruded into the pre-Cambrian or early Paleozoic rocks The massive granite and associated pegmatites in the southern Hills are of pre-Cambrian age themselves However, in the northern Hills many of the mineralized zones are related to Tertiary intrusions (Map 19 A)[26] Of relative insignificance, coal mining was concentrated within the Outer Rim near Cambria and Alladin (Map

[25] Van Royen treats the occupance of the Black Hills under somewhat similar groupings See Van Royen, W, "De Black Hills' van Zuid-Dakota Een sub-humied Eiland in een semi-aried Gebied," *Tijdschr v econ Geographie,* 23 177 188 1932

[26] Emmons, W H, "Relations of Metalliferous Lode Systems to Igneous Intrusions," *Am Inst Min and Met Eng, Trans*, 74 33 1926 See also Connolly, J P, and O'Harra, C C, *The Mineral Wealth of the Black Hills, Bull 16* 270 South Dakota School of Mines, 1929

EXPLANATION OF MAP 19

A Data from J P Connolly and C C O'Harra, *The Mineral Wealth of the Black Hills, Bull 16* (South Dakota School of Mines, 1929), J D Irving *Economic Resources of the Northern Black Hills, U S Geol Surv, Prof Paper 26* (1904), V Ziegler, "The Mineral Resources of the Harney Peak Pegmatites — I' *Mining and Scientific Press*, 108 (1914) 604–608, E P Rothrock "Mineral Producers in 1929," *Report of Investigations, No 1*, South Dakota Geol and Nat Hist Surv (1930), J M Hill, *The Mining Districts of the Western United States, U S Geol Surv, Bull 507* (1912)

B Placement of dots controlled by field data within the Black Hills, and from general knowledge and with the aid of the folios of the U S Geol Surv outside the region

C Data from H S Graves, "Black Hills Forest Reserve,' *U S Geol Surv Annual Rep*, Part 5 (1899), A B Hood, "Logging Operations in the Black Hills," *The Black Hills Engineer* 16 (1928) 120–135, National Forest General Maps of the scale 1 125,000

16 A) A horizon of bituminous coal occurs at or near the base of the sandstone formations underlying the cuesta [27]

The impress on the landscape of the Black Hills by mining is now partly erased, for the majority of the mines, mills, and railways lie idle or have been completely abandoned As late as 1904 there were forty-eight lode mines producing gold, silver, and lead By 1910 the number had fallen to eighteen In 1930 only two were actually in operation [28] One was the Homestake mine, the largest producer of gold in the United States The other was a smaller working on claims at Keystone Mines yielding metals other than gold have experienced very irregular activity, but several small mines in the vicinity of Keystone are being worked at present

The impresses resulting from this mode of occupance are many In 1904 Jaggar stated that "railway branches and loops are now so numerous in the mining district as to form a conspicuous artificial feature of the topography, the same may be said of the innumerable tunnels and prospect holes with their dumps jutting out from the steep gulch slopes, the size of the dump an index to the depth of the digging " [29] At present these features remain merely as mute evidence of former widespread expansion and subsequent decline Many abandoned mining towns, such as Rochford, Galena, Terry, and Trojan, enhance the impression of decadence (Pl LXXVIII, Fig 2) Lead, however, is outstanding as an active mining center, for the Homestake properties are concentrated in its eastern section and present a truly complex industrial scene The town itself has been narrowly restricted by the valley sides, where the houses, rising above one another, overlook the commercial area (Pl LXXX, Fig 1) [30]

Placer mining, which had ceased in 1930, has since then rapidly increased In 1931 eighty-three claims were being worked [31] However, the effect upon the landscape is slight The dispersed popula-

[27] Stone R W, *Coal near the Black Hills in Wyoming and South Dakota, U S Geol. Surv, Bull 499* 1-64 1912

[28] Henderson, C W, articles on gold, silver, copper, lead, and zinc in South Dakota and Wyoming, in various numbers of *U S Geol Surv* through 1923, continued as annual reports by the U S Bureau of Mines, *Mineral Resources*, Part I - 'Metals "

[29] Jaggar, *op cit*, p 16

[30] Guthe, O E, "Lead and Rapid City," *Pap Mich Acad Sci, Arts and Letters*, 18 (1932) 143-149 1933

[31] Henderson, *op cit*

tion at one time dependent on this activity has now been replaced by ranchers

Ranching

The ranching pattern, as indicated by the distribution of crop acreage, is totally different from that of mining Crop production is concentrated beyond the outer edge of the Limestone Plateau on the relatively level areas of the Inner Lowland and the adjoining plains, particularly on the broad alluvial flats where rich soils can be irrigated The more rugged surfaces of the Outer Rim, the Plateau, and the Interior Basin remain today only sparsely settled by ranchers (Map 19 B)

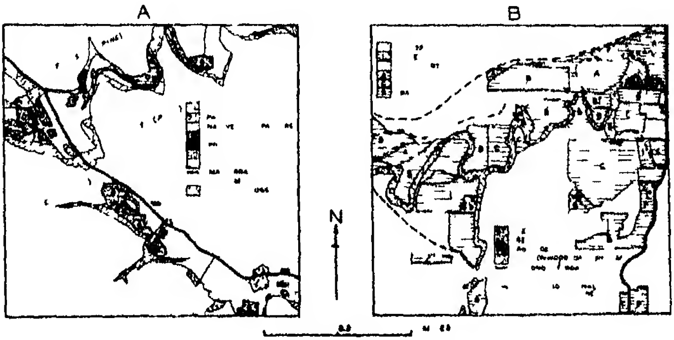
There are three chief types of ranches in the Black Hills the first has a large portion of its crop land under irrigation, the second is the large ranch with extensive fields of grain, from which a surplus is obtainable when the market is favorable and the third is the small ranch, where only forage crops are grown, with occasional plots of potatoes Transitional types can, of course, be recognized Nearly all these ranches involve the raising of stock beef cattle or sheep on the majority of the ranches, but with an increasing specialization in dairy cattle on the irrigated lands near the larger towns

The ranches dependent on irrigation are localized on the broad alluvial flats of the major streams which flow out of the Hills The most noticeable concentration of them is on the eastern and northeastern sides of the Hills, where permanent streams are found Spearfish Valley is the outstanding center for this type of ranching These ranches are not limited to the Hills, but extend to the plains [32] Irrigated fields are dominant and produce forage crops, such as barley, corn, and alfalfa, and also wheat and oats (Map 20 B, Pl LXXVII, Fig 2) Small fields of vegetables, fruit, and sugar beets are also grown Apples are the chief orchard crop, sugar beets furnish part of the supply for the Utah Sugar Refinery at Belle Fourche The irrigation projects within the Hills are privately owned, individually or coöperatively For instance, there are nine leads from Spearfish Creek, and ten or twelve ranchers cooperate in using one ditch

The large ranches with extensive unirrigated fields of grain occur on the better sites for agriculture, on the outer margin of the Lime-

[32] Present and proposed irrigation projects and power developments for this region are discussed in *Cheyenne River, South Dak and Wyo*, *U S* [illegible] *1st Session, House Document No 190* (1932), map 11

stone Plateau, in the Inner Lowland, on some of the more level portions of the Outer Rim and the Upper Belle Fourche Basin, and on the adjoining plains Within the Inner Lowland the concentration of cultivated land on these ranches is in the broad swales where moisture is available and on the low flat terraces where soil drainage is not too rapid for crop production The high gravelly terraces, the exposures of red shale or gypsum, and the highly dissected areas are avoided A few nonforested ridges and valley broadenings on the



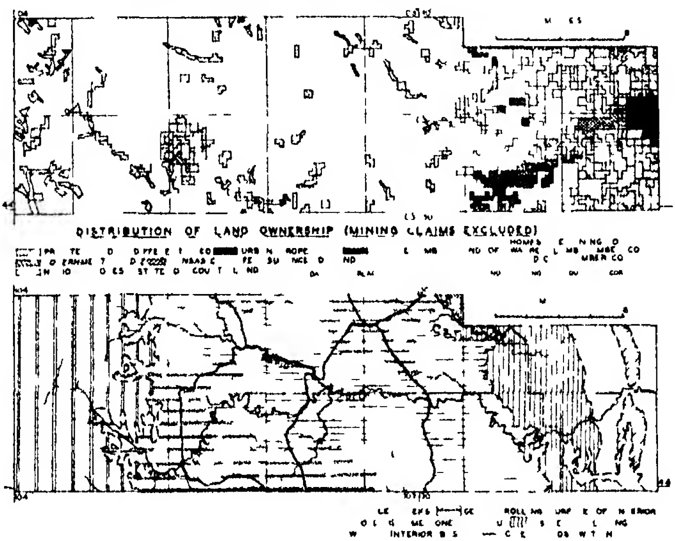
MAP 20 See Map 19 B for the locations of these areas

Outer Rim west of the Inner Lowland are sufficiently extensive to support large ranches The chief crops grown are corn, wheat, and alfalfa, although in some areas oats and barley are important A large proportion of these crops is used for forage, but usually a surplus is available for shipment

Ranches of the third type are relatively small and in nearly all places are restricted to the elongated areas within the grassy parks of the forested zone They are most widespread on the gently rolling surfaces of the Interior Basin and the Plateau (Map 19 B) Occasional ranches are in the deep narrow valleys and gorges in the more dissected portions, but here the fields are very small and are narrowly confined to the valley floors The ranches are mostly homesteads or patented mining claims within the national forests On Map 21 the distribution of privately owned land within the forest is indicative of the agricultural value placed on the various sites, first by the homesteader, but later by the National Forest Service

A marked concentration of such tracts is noticeable on the prairie grasslands and in the parks of the more gently rolling surfaces of the Basin The deeply cut valleys of Rapid and Castle creeks are avoided, but the more rolling surfaces near the eastern part of the Basin are settled, and there seems to be a distinct tendency to locate

A SECTION WESTWARD FROM RAPID CITY SOUTH DAKOTA



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adjacent to the main highways On the ranches of this third type a large portion of the grass is cut for hay, but fields of oats — the dominant grain crop — are interspersed in many places, while potatoes are the money crop The ranch buildings, not uncommonly constructed of logs, stand at the base of the bordering slope, separated from the fields by the road (Map 20 A, Pl LXXVI, Fig 2)

The grazing area is widespread throughout the region and includes timbered and scrub lands as well as grasslands Grazing of cattle on the open range was formerly a thriving industry, but now, with the passing of this range, the rancher has recognized the ad-

vantages offered by the National Forest Service Stock is driven into the Hills every summer and is run on assigned units At the end of the season the cattle are gathered together at shipping points located along the railroads, for most of them are taken to Sioux City and Omaha as feeders The railroad utilized depends upon relative accessibility and rates Sheep are secondary in importance and are restricted within the national forests to a few units, but they are extensively grazed on the plains outside the region

Lumbering

Lumbering, although permanent as an industry within the Hills, is restricted to the area of commercial timber, but presents an ever-changing distributional aspect (Map 19 C) As the cutting proceeds from gulch to gulch the portable sawmills are moved to new working locations, and even the large-scale lumbering activities of the Warren Lamb Lumber Company progress from drainage basin to drainage basin as the available timber is cut In 1926 there were fifty sawmills within the Black Hills region [33]

Scrubby second growth and large burns give evidence of a rapid forest exploitation during the first years of settlement (Map 19 C) Most of the timber was used in the mines, in the wooden buildings of the towns, and in the construction of numerous railroad lines Since 1898 timber cutting has been regulated by the National Forest Service, and it is managed on a sustained-yield basis, which gives permanency to the industry [34]

The settlement forms resulting from the lumbering industry are multiple and are concentrated within the more accessible portions of the forested area Abandoned small sawmill sites can easily be recognized by the large piles of sawdust at the mouths of gulches, the slopes of which have been visibly thinned out At other points the operating mills are seen Logs decked in the woods are a common sight These are awaiting the trucks to take them to the mill

The distribution of the smaller mills is determined largely by the practice of the Forest Service of dividing the area into working circles tributary to definite shipping points These circles are further

[33] Beardshear, W D, "Lumbering in the Black Hills," *The Black Hills Engineer* 14 177 1926

[34] Duthie, G A, 'Timber – an Economic Resource of the Black Hills," *The Black Hills Engineer*, 16 108–109 1928

divided into logging units Each logging unit takes in the drainage basin of a small tributary of one of the larger streams of the Hills The Forest Service allows logging only on those units which are suitable [35] Since the stands of timber suitable for cutting are scattered, the lumbering activity at any one time is also very scattered within the forests

The lumbering activities of the Homestake Mining Corporation are centered around the two camps of Nemo and Moskee (Map 19 C) A large mill has been erected at Nemo, which has been an established lumber camp for thirty-five years It is now a small thriving town, dependent on the activity of the mill For many years a railroad was maintained in operation between Lead and Nemo, but now motor trucks are in use No town has grown up at Moskee, which is secondary in importance to Nemo In 1925 these two sawmills produced about nine million feet BM

The Warren Lamb Lumber Company is the largest operator in the Hills, and in the same year produced seventeen million feet BM [36] Its mill is located on the northwestern edge of Rapid City, easily accessible to the railroads (Map 19 C) The first logging operations of the predecessors of this company began in 1908 Since then the company has logged, in succession, the drainage basins of Victoria Creek, Deer Creek, Galena Creek, Bear Gulch, Slate Creek, Spring Creek, and now Horse Creek (Map 19 C) All these areas lie on the eastern side of the Hills and were made accessible by the construction of temporary railways [37] The railway into the Horse Creek area is still in use Migration of activity is, then, the essence of this mode of occupance

Paradoxically enough, this constant movement of logging operations results in greater permanency of other forms within the Hills Custer, which was in a stage of decadence after the decline of the mining industry in its vicinity, has now become a relatively prosperous town, largely dependent upon the continuous lumbering activities of the working circle for which it forms a center (Pl LXXX, Fig 2) The Nemo working circle serves Nemo in a like manner Otherwise the visual results of lumbering will probably continue to

[35] The Black Hills National Forest and Harney National Forest Records

[36] Beardshear, *op cit*, p 175

[37] Hood, A B, "Logging Operations in the Black Hills," *The Black Engineer*, 16 120-135 1928

appear at new points, mark the immediate landscape for a time, and then later slowly blend with the surroundings

Recreation

Recreation has also tended to retard decline in many parts of the Black Hills The material forms of tourism are definitely concentrated along the main highways in the eastern portion of the Hills (Map 19 D) Here the wooded slopes and the clear, flowing streams form a pleasing contrast to the hot, dry plains in summer Rugged scenery and historical points of interest are also found Rapid City is the center of this recreational activity and forms the gateway for those entering from the east It is from this point that tourist travel radiates into the Hills proper They lie in an advantageous position between the eastern centers of population and the parks of northwestern United States, and graded roads break away from these through routes and invade the interior, only to meet them farther on In this way the impatient tourist experiences but a slight interruption in the continuity of his travel

For many years the tourists were carried through the Hills primarily by trains With the improvement of highways and the increase in motor travel there was a definite shift within the Hills from a concentration along railroad lines to a concentration along highways In 1924 nearly 30 per cent still came by train In 1930 about 95 per cent drove automobiles [38] With the change in the mode of travel the natural recreational resources of the region increased in value as a result of greater accessibility

Graded roads, hotels, lodges, cabin camps, forest trails, golf courses, and many other improvements for the accommodation of this transitory group are seen on all sides The state and national forest and park services combine in their policy of maintaining such features Custer State Park is the largest state park in the United States, and includes some of the most scenic features of the Hills (Map 19 D, Pl LXXVI, Fig 1) The inclusion of Harney Peak and the surrounding heights within the park was a result of the creation of the Custer State Park Game Sanctuary from some of the lands of the Harney National Forest [39] The Meade Federal Game

[38] Harney National Forest Records

[39] Torrey, R H, *State Parks and Recreational Uses of State Forests in the United States* (Washington, 1926), pp 231–234

Refuge west of Sturgis is partly responsible for the preservation and propagation of the game life within the region The Federal and state fish hatcheries at Spearfish and Rapid City supply many thousands of rainbow, brook, and black-spotted trout to the larger streams each year [40] Unique attractions under governmental control are Wind Cave National Park, Jewel Cave and Devil's Tower national monuments, and, more recently, the Rushmore Memorial (Map 19 D)

These features, to which might be added many other points of interest to the tourist, are individually of little significance as a part of the areal scene, since each is unique in the area On the other hand, as an aggregate they have directed the spread of recreational activity and its associated forms within the region

From the blending of the patterns recognized in the preceding analysis the unified whole of the cultural impress is seen in all its complexity This complexity is functionally exemplified in Rapid City, which has grown into the largest urban center of the Hills (Pl LXXIX, Fig 2) It serves its territory in many ways, all of which are noted in the urban scene Of outstanding importance is the commercial function, for Rapid City is a point upon which routes converge Its trade area includes the entire Hills and the adjoining plains Mining is reflected in the State School of Mines, ranching in the flour mills and creameries, lumbering in the Warren Lamb lumber plant, and the recreational activity in the several large cabin camps and camping grounds, as well as in hotels, which are far too impressive for the actual size of the city [41]

Conclusion

These types of economic activity and the design given to the areal scene of the Black Hills by the union of the patterns of the physical background with those of the occupance result in a recognized unity — an insular quality which definitely separates this region from the expanse of the Northern Great Plains

The gross features of the mold, recognizable in the major lineaments of the surface, seem to dominate the patterns of the other elements of the areal scene The general patterns of the soil, the

[40] Booth, D C, "Fish Culture in the Black Hills," *Pahasapa Quarterly*, 1, No 4 16–17 1912

[41] Guthe, *op cit*, pp 150–155

forests, the grasslands, the population distribution, and the roads, for example, conform to the major expression of the mold Each mode of occupance has brought an individual pattern of forms associated with it Mining is concentrated within the Interior Basin Ranching reaches its best development on the outskirts of the Hills Lumbering, less restricted than mining, has expanded from the Interior Basin to the Limestone Plateau Recreational features alone deviate from the major lineaments

The drainage pattern, on the other hand, reveals the minor irregularities of the mold and forms the skeleton in relation to which the details of the landscapes align themselves The valley parks of the Interior Basin and the irrigated alluvial flats of the Inner Lowland, for example, conform with the drainage lines, but are diametrically opposed to the alignment of the gross features

These major and minor lineaments bring out separate distributions which, blending together, create the regional design of the Black Hills

University of Michigan

PLATE LXXV

Fig. 1. An aerial view of the Harney Peak District. The type of surface is one of the most rugged in the Black Hills region. The bare faces of massive granite outcrops are prominent.

Fig. 2. A characteristic park within the Interior Basin. The surface shows the moderate relief of late maturity. The typical zonation of vegetation can be seen partly developed. The native hay in the foreground has just been cut. The road follows along the base of the ridge just to the right of the view. Photograph taken looking northwestward in the valley shown on Map 20 A.

PLATE LXXVII

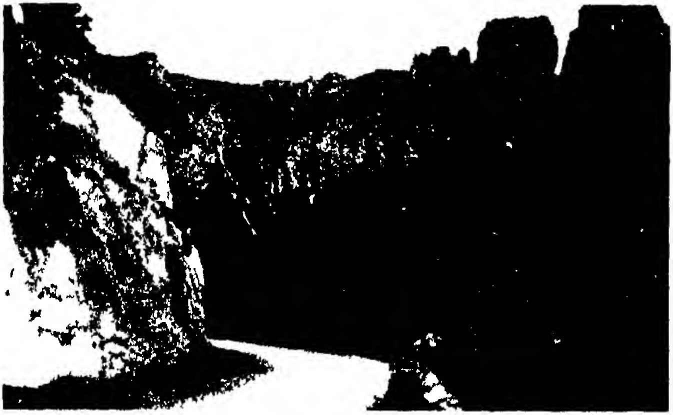


FIG. 1. A gorge cut into the Limestone Plateau. Evidence of recent burning. Photograph in the burned-over area southwest of Spearfish.

FIG. 2. A view of some alluvial flats within the Inner Lowland. In the background are flat-topped hills capped by terrace deposits on the hilly surface of the Lowland. The stream is bordered by cottonwood. A field of corn is on the left and a field of barley on the right. Photograph taken looking southward over the area shown on Map 20B.

PLATE LXXVIII

FIG. 1. The valley of Castle Creek at the inner edge of the Limestone Plateau. The limestone escarpment appears in the background. Here is an excellent example of the zonal arrangement of vegetation. A small tributary in the foreground is lined with willow. The main stream in the center is similarly indicated. The intervening area is meadow grass and is cut as seen in the foreground. Aspen cover the lower slopes. Some pines are seen, but stands of spruce cover the north facing slope.

he mining town of Rochford, now practically abandoned. It lies in the valley of Rapid Creek within the Interior

PLATE LXXIX

FIG. 1. Abandoned ranch buildings located on the side of a shoal within the forested area. An early type of structure with log construction and characteristic chinking is shown here.

FIG. 2. An aerial view of Rapid City, looking eastward.

PLATE LXXX

A view of the commercial and residential sections of Lead looking northwestward. The Homestake mills are to the right of the view.

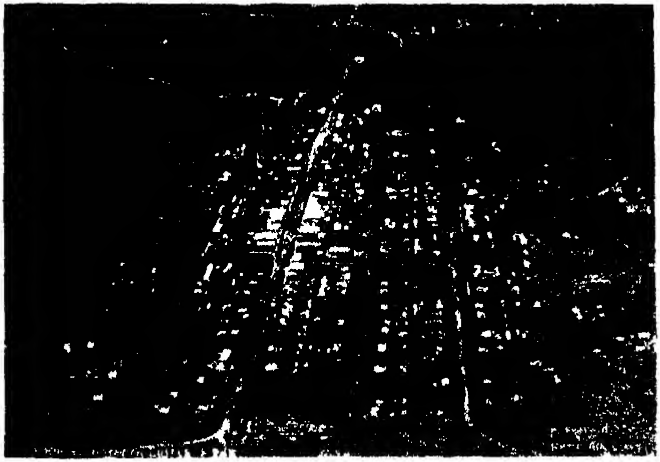


FIG. 2. An aerial view of Custer looking westward. The grassy valley parks in the background are characteristic of this part of the Interior Basin. The rectangularity of the street pattern is unusual for towns within the

THE CENTRAL PYRENEAN PIEDMONT OF FRANCE

HENRY MADISON KENDALL

THOUGH the Aquitain Basin (Map 22)[1] of southern France is commonly regarded as one of the major geographic units of the European continent,[2] it can in no way be thought of as an undifferentiated lowland of uniform landscape. Morphologically, it is distinctly set apart by Brittany and the Massif Central on the north and east, by the Atlantic Ocean on the west, and by the high rampart of the Pyrenees on the south. One opening to the north, the Gate of Poitou (Poitiers), and one to the southeast, the Gate of Carcassonne, break through the otherwise well-defined rim of this saucer of land, half-covered by the Atlantic Ocean. In spite of these outlets, the land looks westward to the open ocean, whence come the rain-bearing winds which make it well watered. Some of its area is without a dense population and is admirably adapted to pastoral pursuits. Other portions with a greater density of population have characteristics eminently fitted to agriculture. It is not a land of industry, for it lacks the natural resources upon which modern industry is based. It is dominantly rural, though its major cities are born of the importance of commerce. From this point of view the Aquitain Basin is a clearly recognizable unit. When detail is examined, however, the variety of landscape expression becomes evident, and sectional differences assume paramount importance.

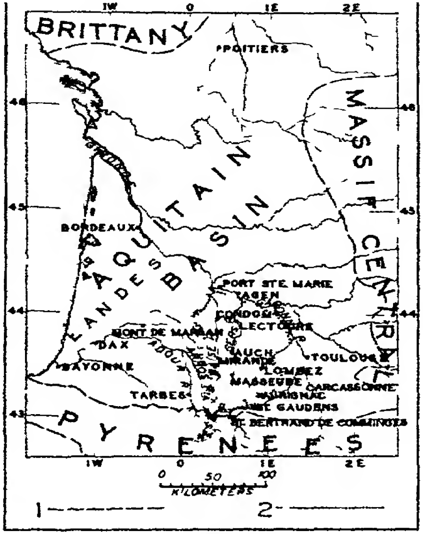
One of the group of tiles which, placed together, make up the mosaic of landscape of the whole Aquitain Basin is the Central Pyrenean Piedmont. It is known by a variety of *pays*[3] names, of

[1] Map 22 shows place names mentioned in the text. No further reference to this map will be made.

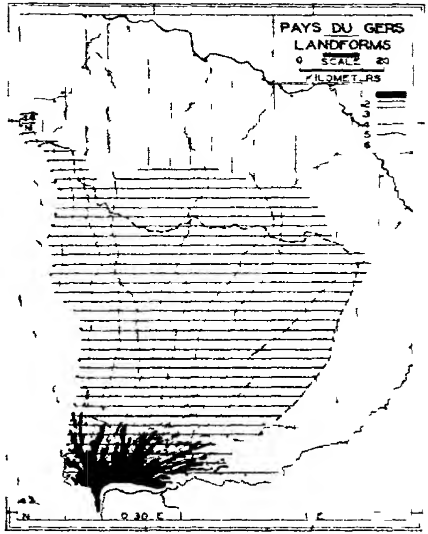
[2] Vidal de la Blache, Paul, *La France* (Hachette, Paris, 1908), De Martonne E., *Les Régions géographiques de la France* (Flammarion, Paris, 1921), Fèvre, Joseph, and Hauser Henri, *Régions et pays de France* (Alcan, Paris, 1909).

[3] Gallois, L., *Régions naturelles et noms de pays* (Colin, Paris, 1908). See particularly Chapters I, II, XI, and XII.

A *pays* is an area which is popularly thought of in France as one of essential



Map 22



Map 23

Map 22 Southwestern France. Explanation of symbols 1, limits of major physiographic regions, 2 limits of the Pays du Gers

Map 23. Based in part on a map by L A Fabre, "Le Front nord des Pyrénées centrales et les hautes vallees gasconnes," on a scale of 1 200,000, in *La Géographie*, 11 (1905) Plate 3 Explanation of symbols 1 undissected surface of the plateau of Lannemezan, 2, zone of asymmetrical valleys 3 zone of mature interfluves and mature valleys, 4, northern and eastern limit of youthful valleys, 5, northern and eastern limit of youthful interfluves, 6, limits of the Pays du Gers

which the collective *Pays du Gers* seems well suited, even though this is an extension of the usual sense in which that name is used Pays du Gers and Central Pyrenean Piedmont of France may be used interchangeably

THE SETTING

The Pays du Gers forms a distinct geographic region, though, because of its considerable area, which is about 8,500 square kilometers, it presents noticeable variety of detail throughout It is set off clearly on three sides, but to the west it blends with other portions of the piedmont To the south it is cut off by the Pyrenees and the valley of the Neste [4] while to the east and north it is delimited by the ribbon-like plain of the Garonne To the northwest lies the expansive, low, sandy plateau of the Landes [5] The limits have been recognized not on the basis of surface character alone, but from the aspect of the surrounding land as contrasted with that of the land inclosed within the bounds mentioned

Surface configuration and hydrography

There is a continuous gradation of surface and drainage forms from the Pyrenean front to the Garonne Valley Three zones of combined forms may be recognized They are first, the nearly level plateau surface with incipient drainage, second, the section of asymmetrical valleys [6] with asymmetrically placed major streams and youthful interfluves grading northward into mature ones, and, third, the zone of late mature valleys with widely meandering streams

unity in both the forms of the fundament and those of the occupance In many instances, though not invariably, this concept holds true Pays are of several orders of magnitude as, for example, in Condomois, which is part of Haut Armagnac The latter is, in turn, part of the larger pays of Armagnac and also part of the Pays du Gers The limits of a pays are not always determined by exact criteria but, rather, by common usage The names of many of the pays of France are so well recognized that their usage technically as well as popularly is common

[4] Sorre, M , *Les Pyrénées* (Colin, Paris, 1928), pp 138 141

[5] De Launay, L , *Geologie de la France* (Colin, Paris 1921), p 291

[6] The cause of asymmetry of the valleys of the Pyrenean piedmont has been a much-discussed problem for which no completely satisfactory solution has as yet been offered See Laurant, Gustave, "L Armagnac et les pays de Gers, *Ann de géog*, 20 145 1911, Fabre, L A , "La Dissymétrie des vallées et la loi dite de De Baer, particulièrement en Gascogne," *La Géog*, 8 291–306 1903, Réclus, É , *La France*, Vol II in *Nouvelle géographie universelle* (Hachette, Paris 1877)

separated from one another by belts of maturely dissected inter-stream spaces

A broad expanse of nearly level land stretches northward from the front of the Central French Pyrenees (Map 23, Pl LXXXI, Fig 1) This is the plateau of Lannemezan, all that remains of a formerly more extensive mass of fluvio-glacial detritus[7] The apex of this deposit is on the slope of the mountain which forms the left bank of the upper Neste Valley From that point the land descends gradually and spreads out like a fan northward Numerous streams, all contributing to the volume of the Garonne except a few which bathe the western edge of the mass, have cut their way headward into the fan, so that the present northern edge of the plateau is a succession of narrow, flat-topped, finger-like ridges separated from one another by steep-sided, V-shaped valleys (Pl LXXXI, Fig 2)

These finger-like remnants extend as much as thirty kilometers from the apex of the fan (Map 23) With increasing distance from the mountains they become narrower, and the valleys between them become wider and less notched They are asymmetrical in cross-section with, usually, steep eastern walls and gentle western ones Their floors are filled with alluvium, both ancient and recent They are definitely aggraded

Beyond the latitude of Auch there are few youthful remnants of the upland surface Northward the country appears to be made up of several lines of well-rounded hills The valleys which separate them present the characteristics of late maturity or old age They remain asymmetrical somewhat farther to the north, however

As the Garonne River is approached, the valleys become narrower and the interfluves are more prominent They break away sharply to the Garonne lowland over two levels of terraces,[8] which are well defined except where the river is sapping its southern valley side All the affluents of the Garonne on its left bank cut trenchlike valleys through these terraces Though these valleys are not wide or deep, they produce a surface which is dissimilar to that in the hilly land to the south This surface marks a distinctive change of landscape between the Pays du Gers and the plain of the Garonne

[7] Fabre, L A, "Le Sol de la Gascogne," *La Géog*, 11 257–284, 343–358, 413–434 1905

[8] Chaput, E "Recherches sur l'évolution des terrasses de l'Aquitaine," *Bull, Soc d his nat de Toulouse,* 56 17–100 1927

Only along its northern edge is surface water to be seen on the plateau of Lannemezan The main body of the upland is not fretted with valleys, nor are there any lakes or marshes on it In some places the water table approaches the surface, and, here and there, temporary bogginess may occur The northern edge is quite different Here the headward cutting of the streams forms a very deeply indented surface, both vertically and horizontally It is the streams and their valleys that limit the plateau proper The upper portions of the streams form an integral part of the surface in that they are the vital force which controls this limit, now more or less fixed by the intervention of man [9] Beyond this limit there is a different complex

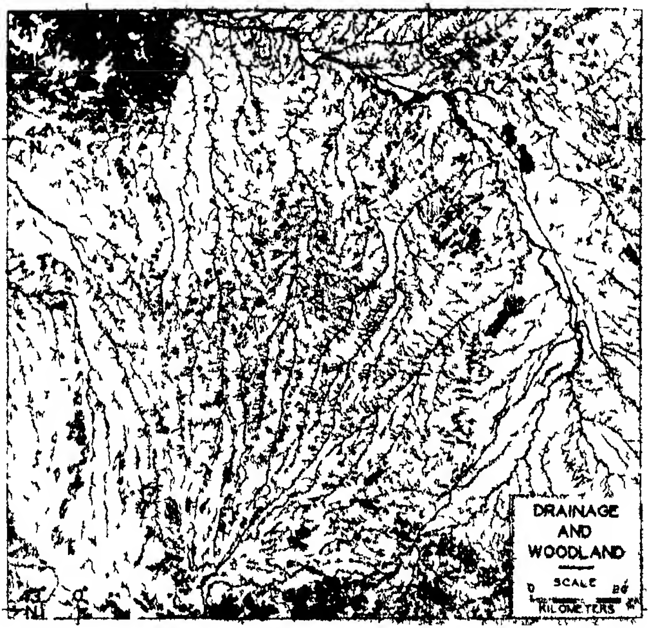
Almost throughout the zone of outstandingly asymmetrical valleys the steep right banks of the streams and the gentle, though latitudinally serrated surface of the left banks, are separated by the flat valley floors of ancient and recent alluvium into which the present rivers are cutting (Pl LXXXI, Fig 3) In a few places the left bank is the steep one while the right bank is gentle The relief of any one of the three surfaces is the result of the carving of the tributaries, except the channels of the main streams The secondary streams have not progressed to the erosional stage of the major rivers and have cut only V-shaped valleys They produce on any one surface a washboard effect This roughening is found almost without exception on the surfaces of gentle slope The few torrential rivulets of the steeper slopes [10] cut ravines which advance headward rapidly and indent the sky line of the valley sides to a greater depth than those of the opposite banks

In the lowest, or northernmost, zone there is found a country which, if one looks eastward or westward, presents the appearance of an ocean breaking against a shore Northward or southward the likeness is not lost, it merely appears, from the valleys, as though one were in a trough between two waves, or, from the interfluves, as though one were on the crest of a wave Water has worked upon the land to reduce it until a veritable labyrinth of rivers, brooks, and rills separates isolated, gently rounded hills (Pl LXXXII, Fig 1)

[9] Cavaillès, H, "La Houille blanche dans les Pyrénées françaises," *Ann de géog*, 28 450 1919

[10] Fabre, L A, "Sur le déplacement vers l'est des cours d'eau qui rayonnent du Plateau de Lannemezan," *Compte rendu Acad scs de Paris*, 127 204 1898

The stream pattern corresponds to the zonal arrangement of surface forms (Map 24) The rivers flow in a radial pattern from the plateau of Lannemezan in a general northward direction to their confluences with the Garonne Near their headwaters they follow



MAP 24 The Pays du Gers and surrounding area Based on Carte de France à 1 200,000 — 1927 édition

rectilinear courses and have few tributaries Farther northward the number of tributaries, particularly on the left banks of the main streams,[11] is increased and the pattern is comblike In the northernmost zone the number of small tributaries is decreased while that of large tributaries is increased There the pattern is dendritic in detail Throughout their whole length the radial arrangement of the streams from the plateau is fundamental Other detailed patterns

[11] Fabre, *op. cit*, p 203

which are encountered are amplifications of this or are combinations of it with others

The reaction of the streams to the climatic régime can be noted clearly The period of highest water is usually during April and May, and it is followed by a period of extreme dryness In July and August there is very little water in the major streams, and many of the smaller ones are completely dry (Pl LXXXI, Fig 3) From September onward there is a gradual increase in flow until a maximum, which is only slightly lower than that of early summer or late spring, is reached in December After this there is a slight decrease until the end of January, when increased flow is again noticeable

More startling than the seasonal changes are the changes induced by short periods of heavy rainfall The effectiveness of storms is due, in part at least, to the impermeability of the soil near the headwaters of the streams and on the steeper slopes [12] The reaction of the streams to sudden storms has long been noted [13] A heavy rain of a few hours' duration produces a flooding of the flat valley floors of any of the major valleys Evidences of human attempts at protection from these sudden floods, such as the retaining walls which line the Baïse at Condom, bear witness to the rapidity with which the streams answer to the changes in weather (Pl LXXXII, Fig 2)

Since the construction of the canal along the edge of the plateau of Lannemezan there have been fewer disastrous floods at the high-water periods, and the severity of the droughts has been considerably lessened,[14] but the regimen of the rivers has been very little affected Their flow bears little relationship to the snow accumulations of the Pyrenees and can be more completely related to the rainfall régime of the Aquitain Basin as a whole [15] There is variability throughout the basin, and the amounts of water in the various rivers decrease relatively as one proceeds eastward The regimen does not vary, however

[12] Lemoine, Georges, "Essai sur l hydrométrie du bassin de la Garonne," *Ann de géog*, 5 368 1895–96

[13] One of the earliest accounts is included in Venatius Fortunatus, "De Egircio flumine," *Venance fortunat*, translated by Charles Nisard and Eugène Rittier (Firmin-Didot Paris, 1887), pp 58 59

[14] Cavaillès, *loc cit*

[15] Lemoine, *op cit*, p 371, Angot, Alfred, "Régime pluviométrique de la France (Deuxième partie Régions sud-ouest et sud)," *Ann de géog*, 27 1–27 1919

Climate

The climate of the Pays du Gers is that which is found typically a short distance inland from the west coasts of continents in the middle latitudes. Though it shows a transitional character between marine, continental, and mountain climates,[16] there is a normal marine modification of maxima and minima of temperature and rainfall. There are no periods of extremes of heat or cold, and exceptional wetness or drought is not general. The position of the Pays du Gers, open as it is to the Atlantic and the Mediterranean winds, but shut in to the south by the Pyrenees, is the dominant feature of the local climatic control.

The climatic statistics for Auch [17] may be taken as typical of the whole region. The temperature is given in degrees Centigrade and the rainfall in millimeters. They are as follows:

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Temperature	4.0	6.3	8.2	10.4	14.7	17.2	19.4	19.9	17.1	13.0	8.0	6.0	12.0
Precipitation	53	42	52	73	77	75	50	47	58	58	54	50	689.0

Soil

The soil, as recognized in its climatic soil group by Agafonoff,[18] is of the Brown Forest type.[19] Well-developed profiles are to be found in only a few places. In general, the soils of the steep eastern valley sides are being constantly removed by sapping and gullying as well as by soil creep. Consequently, whatever profile might have been developed is not now visible in its entirety. On the gentle western valley sides the covering of alluvium masks whatever development there has been. Under the mask it is possible to make out poorly developed profiles. On the valley floors recent alluvium,

[16] In terms of the Köppen classification the type is Cfb. For criteria see Köppen, W., *Die Klimate der Erde* (De Gruyter, Berlin and Leipzig, 1923), particularly pp. 120-121, 155-157, 262-267. In terms of the Thornthwaite classification it is BB'r. For criteria see Thornthwaite, C. W., "The Climates of North America according to a New Classification," *Geog. Rev.*, *21*: 633-655, 1931. See also a map of the climates of the world prepared and distributed by C. W. Thornthwaite at the annual meeting of the Association of American Geographers held at Ypsilanti, Michigan, in December, 1931.

[17] Bernhard, Hans, *Landbauzonen, ländliche Entvölkerung und landwirtschaftliche Einwanderung in Frankreich, mit besonderer Berucksichtigung der schweizerischen Ansiedlung in Südwestfrankreich* (Kümmerly & Frey, Bern, 1927), pp. 97, 99.

[18] Agafonoff, V., "Les Types de sols de France," *Annales de la science agronomique française et étrangère*, 2: 97-120, 1928.

[19] See Stremme, H., Allgemeine Bodenkarte Europas (Danzig, 1927).

which is being added to constantly, prevents the formation of distinct horizons. Only in the undissected remnants of the plateau of Lannemezan have the soil-forming processes gone on undisturbed for a time sufficiently long to permit the formation of horizons which correspond to those by which the Brown Forest soil may be recognized. Even here the influence of parent material appears to remain.

Vegetation

The region lies within the belt of mixed hardwood forest, though very near its equatorward margin.[20] The beech family, represented dominantly by numerous oaks, constitutes the remnants of woodland left at present (Map 24). In view of the position of the area as regards climate and soil, it may be said that this family of trees was the most common in the past. Where the original cover has been removed and the land is not under cultivation, the forest returns slowly. Partly as a result of this, the valley bottoms are now dominantly grass-covered, with fringes of trees along the water courses (Pl. LXXXII, Fig. 3). The surface of the plateau of Lannemezan is now moorland (Pl. LXXXI, Fig. 1), though its original cover was probably similar to the present woodland elsewhere throughout the region.

In respect to the trees present the area is transitional between the Mediterranean and the oceanic categories of Gaussen.[21] Three types of deciduous oaks (*Quercus pedunculata* Ehrh., *Q. Robur* Willd., and *Q. pubescens* Willd.)[22] are dominant, though ironwood (*Carpinus Betulus* Tourn.), chestnut (*Castanea vulgaris* Link), maple (*Acer campestre* L.), sycamore maple (*Acer pseudoplatanus* L.), black locust (*Robinia pseudo-acacia* L.), hazel (*Corylus Avellana* L.), and hawthorn (*Crataegus oxyacantha* L.) are also common trees throughout. The evergreen oak (*Q. Ilex* L.), the cork oak (*Q. Suber* L.), and the olive (*Olea europaea* L.), suggesting westward extension of the Mediterranean type, are not numerous, but all of them exist

[20] A careful though brief, statement of the present detailed character and distribution of the vegetation of the southeastern part of the area is included in Gaussen, H., *Végétation de la moitié orientale des Pyrénées* (Lechevalier, Paris 1926), pp. 348–368.

[21] *Op. cit.*, p. 348.

[22] All specific names used are those listed in Mouillefert, P., *Traité des arbris-seaux*, Part I, Librairie des Sciences Naturelles (Paris, 1892–1898). American usage has been followed with respect to the capitalization of specific names.

even beyond the western boundary of the Pays du Gers The Scotch pine (*Pinus sylvestris* L) occurs quite frequently in areas of sandy soil Fir (*Abies pectinata* DC), spruce (*Picea excelsa* Link), larch (*Larix europaea* DC), and beech (*Fagus sylvatica* L) add a more northerly character to the woods in the few localities in which they occur

Along the stream courses willow (*Salix alba* L , *S amygdalina* L , and *S viminalis* L), alder (*Alnus glutinosa* Willd), and several varieties of poplar (*Populus nigra* L , *P tremula* L , and *P alba* L) form regular dense fringes Other than in these fringes trees occur only in hedgerows on the valley floors Prairies and meadows, interrupted by a few cultivated fields, make up the remainder of the covering As one proceeds southward toward the plateau of Lannemezan, the grasslands of the valleys are less extensive (Pl LXXXIII, Fig 1) They finally give way to brush or deciduous oak cover

The plateau and its finger-like extensions are fringed with this oak woods, which ceases abruptly near the 600-meter contour On the plateau the vegetation is moor, except for a few scattered areas of oak woods (Pl LXXXIII, Fig 2) Furze (*Ulex nanus* Sm to the west and *U europaeus* L to the east) and heather (*Calluna vulgaris* Salisb) are dominant on this moorland, though two of the heaths (*Erica tetralix* L and *E vagans* L) are found in the association Their existence in place of a forest cover is a cultural matter The continued pasturage of sheep on the plateau has done much to make natural reforestation ineffective [23]

Originally the Pays du Gers was nearly completely forested, with occasional grassy patches along the streams [24] The exceptions to the forest cover were edaphic and not climatic The present state of the forest covering is an expression of the use which man has made of the area and not of the inherent fundament characteristics

The base of human occupance

The complex of these features of the fundament make up the base for man's activity in the area The Pays du Gers is definitely set off

[23] Fabre, L A , "Les Landes de Lannemesan," *Rev de Comminges*, 13 260 1898

[24] Laurant, Gustave, "Armagnac et pays du Gers," *Rev de Gascogne*, 53d year, New Series, 12 453 1912, Fabre, L A , "L'Érosion pyrénéenne et les alluvions de la Garonne," *Ann de géog* , 11 38 1902

from surrounding regions and in this respect is typical of the whole northern piedmont of the Pyrenees It is the largest of the many fans which spread out from the mouths of the Pyrenean valleys into the central declivity of the Aquitain Basin For this reason its parts are more clearly defined than similar features of the other fans It occupies a central position with reference to the Pyrenean front, and appears, therefore, to be the culmination of all the sedimentary deposits of the basin It is a very prominent part of the Aquitain region

The land surface is fundamental The original feature of a cone of detrital material piled up at the base of a mountain range is essentially unchanged From a valley worn deep by glacial action it extends, gradually decreasing in elevation, to the median line of the basin where flows the Garonne River Back from this broad stream tributaries have eaten radially disposed valleys into the sides of the cone They have all but removed the original surface, leaving, to the north, wide valleys with hilly interfluves, and, farther south, narrowing asymmetrical valleys with flat-topped interfluves, until finally the V-shaped valleys which scallop the edge of the plateau of Lannemezan are reached, and the remnant of the old surface, little disturbed, is attained This is the base into which the ultimate roots of human life in the region are grown, and from which have sprung the fruits of that occupance

POPULATION

Human beings have lived in the Pays du Gers for a very long period of time The earliest occupance of the area about which anything is known was during the Paleolithic period Aurignac, the type station of the Aurignacian subdivision of the Paleolithic,[25] lies near the southeastern edge of the region Neolithic remains, both at Aurignac and at other points throughout the area, can lead only to the conclusion that human occupance has been continuous since early Paleolithic times [26] The evidences of early occupance are not areally important in the present landscape, however

Occupance in historic times has continued to mold the landscape

[25] Burkitt, M C, *Prehistory* (University Press, Cambridge, 1925), p 11

[26] Astre, Gaston, "Débris squelettiques d'une race néolithique de petite taille découverts à Vic Fezensac," *Bull Soc d'hist nat de Toulouse*, 52 117-132 1924

into its present form It is known that the Phoenicians had reached the Aquitainian coast in the fifteenth century B C ,[27] and that they had trade relations with the people of the interior as well as with those along the coast The land was well known to the Greeks and is briefly mentioned by Strabo[28] It came under the influence of Rome and existed as a separate province

Many of the towns are at least of pre-Roman date of establishment, and they indicate the almost static position of life within the area since that time It was well known then as an agricultural area, and it still remains so in essence It has been many times contested for by Greeks, Romans, Goths, Moors, Spanish, and English, and only in relatively recent times has it come under French domination The continual influx of cultural elements has not caused any sudden and emphatic change in the character of the occupance Rather, various items of all the cultures have been fused into one mass, which makes up the present cultural phase of the landscape The effect of these culture infusions may be measured in terms of the nature of the population and its distribution, the pattern of circulation forms, and the use of the land, but to estimate the part which belongs to each of the long series of cultures would be impossible, for they have been completely blended

The nature of the population

The population of this part of France is very uniform in type The inhabitants during the pre-Christian era were of the Iberian group of peoples,[29] and, despite the fact that invasions of other peoples have been recurrent, this fundamental stock has been little changed

Successive waves of people, constantly overriding western Europe, plundered the land, but, with the exception of the Vascon influx from Spain, the invaders did not settle in considerable numbers The Vascons were Iberian peoples, and consequently the character of the inhabitants of the region was not greatly altered when they came For all others the Pays du Gers proved simply an obstacle to be

[27] Guilbert, Aristide, *Histoire des villes de France* (Claye, Paris [1844 48?]), II 203

[28] *Geography*, translated by Horace Leonard Jones (Heineman, London, 1928), 4, 2, 1

[29] Bertrand, Alexandre, *Nos origins La Gaule avant les Gaulois* (Leroux, Paris, 1891), p 248

overcome during the invasions rather than a coveted prize, though no satisfactory explanation has been made why this land should have been passed over by the invaders. Even after it had become part of France in 1453[30] the people remained isolated as a nearly foreign group.

During the last few centuries there have been minor infiltrations of people of other nationalities. Spanish[31] and Italians[32] are the most numerous, though there has been, in recent years, an influx of Swiss to the western part of the Pays du Gers.[33] Only very slowly have these people been absorbed. The inhabitants have remained nearly as free from admixtures as the Basques.

The present population is distinctly a rural one. The French census lists classes of population on the basis of the size of agglomeration in which the people live. Agglomerations of over 2,500 people are considered urban, whereas those of smaller size down to the individual house are considered rural. In the 1926 census,[34] the population of the whole of France is given as 40,743,854, of which 19,984,720 are listed as urban dwellers. The Department of Gers, which may be taken as representative of the Pays du Gers for statistical purposes,* is listed as having a total population of 196,419, of which only 26,250 are urban dwellers. For the whole of France the population is 49 per cent urban whereas, in the Department of Gers, it is only 13 per cent urban. The rural character is further emphasized by the consideration of the proportion of persons engaged in agriculture. In France as a whole, in 1921, 23 per cent of the people were engaged in agriculture, whereas in the Department of Gers 48 per cent were so engaged.

The one basically geographic cause of depopulation[35] in the Department of Gers since 1846 (see Table I) has been industrialization and urbanization in other parts of France. To these other centers

[30] Williamson, James A., *Maritime Enterprise, 1485 1558* (Clarendon Press, Oxford, 1913), p. 208.

[31] Caziot, Pierre, *La Valeur de la terre en France* (Baillière, Paris, 1914), p. 332.

[32] Granat, O., *Géographie du Lot et Garonne* (Agier, Agen 1929) pp. 44 and 45.

[33] Bernhard, *op. cit.*, Pl. 32.

[34] *Résultats statistiques du recensement général de la population effectué le 7 mars 1926* (Impr. Nationale, Paris, 1928).

[35] Other phases of the question of the depopulation are discussed in Labat, Emmanuel, "En Gascogne: L'Abandon de la terre," *Rev. des deux mondes*, 80th year, 5th period, 58: 635-668, 1910, and *idem*, 'En Gascogne: À propos du problème de la natalité,' *ibid.*, 81st year, 6th period, 4: 62-95, 1911.

TABLE I[36]

POPULATION OF THE DEPARTMENT OF GERS

1790	268,800	1846	314,885	1886	274,391
An VIII[37]	270,609	1851	307,479	1891	261,084
1806	295,021	1856	304,497	1896	250,472
1821	301,336	1861	298,931	1901	238,443
1826	307,601	1866	295,692	1906	231,088
1831	312,160	1872	284,717	1911	221,994
1836	312,882	1876	283,546	1921	194,406
1841	311,147	1881	281,532	1926	196,419

For 1926	Agglomerated	72,134
	Scattered	121,132
	Others, including troops etc	3,153
	French	184 335
	Others	12,084
	Houses	57,315
	Households	54,807

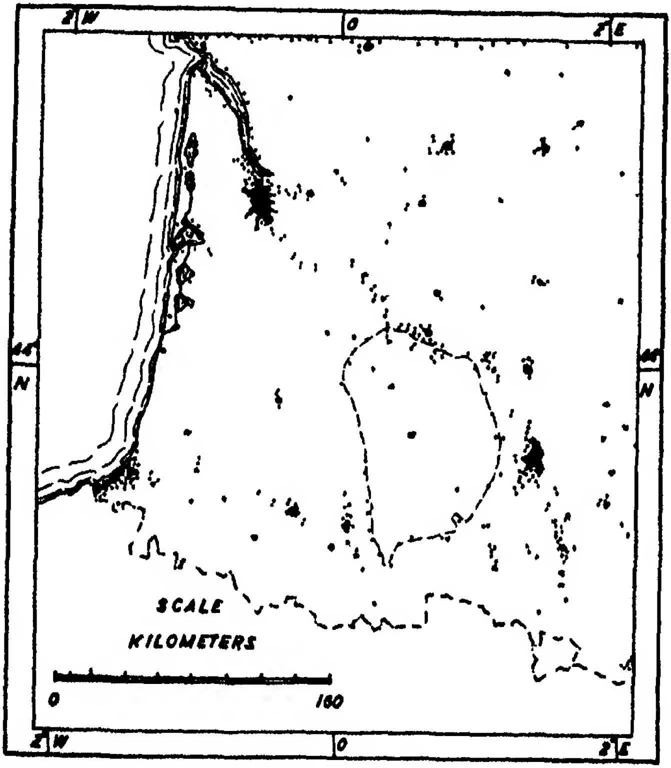
many of the younger people of Gers have gone, and few of them have ever returned The character of Gers does not permit within its confines the growth of large cities which might combat this trend Gers is a rural portion of France and by its own equipment it is forced to remain so There has been a growing dislike for rural life during the last two generations, combined with the rise of the feeling that agriculture is not a desirable pursuit The area can provide food, clothing, and shelter, but moneyed wealth is not to be found The large city calls up illusions of great wealth and easier life than the farm As a result, the youth of the country are strongly tempted to leave and do so Thus the Pays du Gers loses population to other sections of France where rural life is not predominant

The distribution of population

In contrast to that of surrounding regions, the population of the Pays du Gers is quite sparse (Map 25) The Garonne lowland forms a winding band of nearly evenly distributed population from the large seaport agglomeration of Bordeaux to the inland center of Toulouse Even beyond this latter place the band continues until the immediate pre-Pyrenean valley is reached To the west a triangular area of dense population exists between Bayonne, Tarbes, and Mont-de-

[36] *Annuaire administratif du Gers pour 1930* (Cocharaux, Auch, 1930), p 57

[37] *An VIII* in the calendar of the French First Republic corresponds to the period between Sept 22, 1800, and Sept 16, 1801, of the Christian calendar

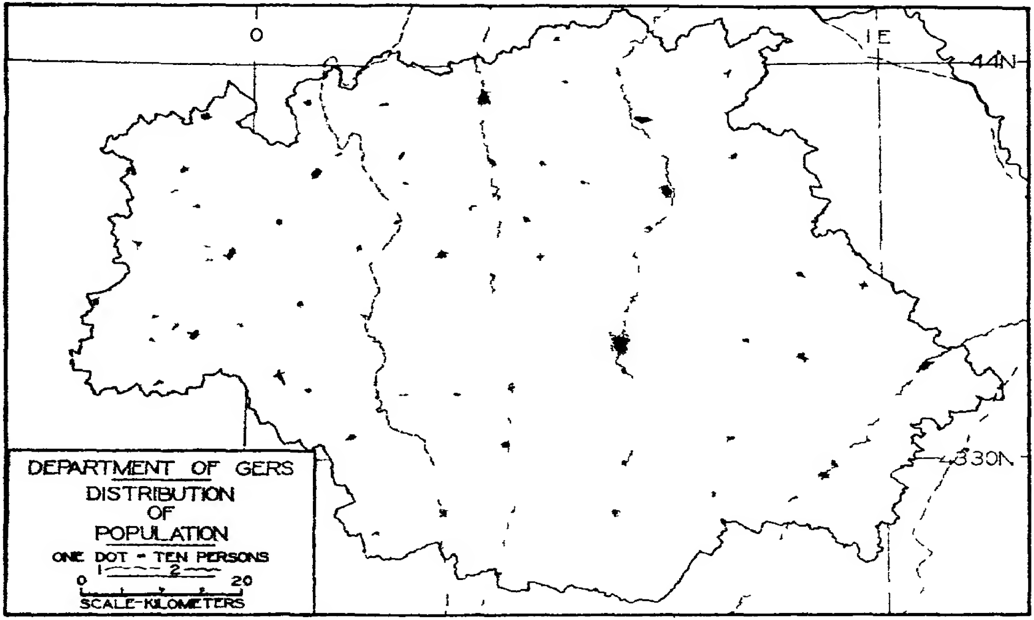


MAP 25 Population of southwestern France according to the census of 1926 One dot equals 2,000 persons Dashed line indicates the limits of the Pays du Gers

Marsan Of all the surrounding regions only in the Landes is a sparser population and a more scattered one to be found

In detail, the population of the Central Pyrenean Piedmont is distinctly disseminated [38] (Map 26) A rather even spread with

[38] Statistical data for the Pays du Gers as a whole are not available, and hence only for that portion which lies in the Department of Gers has it been possible to construct a detailed map of population distribution



Map 26 Explanation of symbols: 1 limits of the Pays du Gers, 2 limits of the Department of Gers Statistics from *Annuaire administratif statistique, historique, et commercial du Gers pour 1930* and from *Résultats statistiques du recensement général de la population effectué le " mars 1936* Position of dots controlled by position of houses shown on the Carte de France à 1 50 000 — 1926 edition

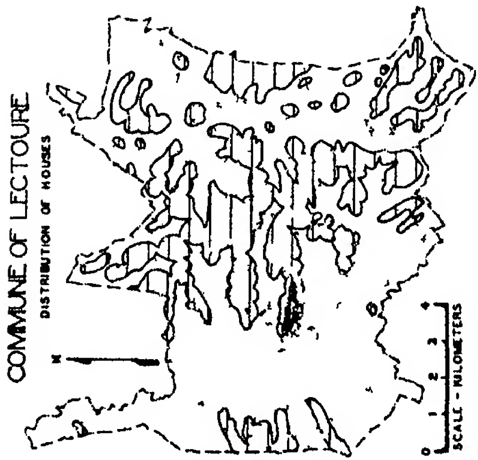
many scattered nuclei is to be noted The largest of the nuclei is the city of Auch, with 12,500 inhabitants This is the only urban agglomeration within the area To the north of the city the dissemination is quite even, as is also the spotting of nuclei throughout it To the south of the city the spread is more uneven, and the groupings are fewer and smaller A closer examination of the patterns of two small sections will serve to show the essential differences between north and south

The first of these small sections is the commune of Lectoure, which is in the north-central part of the Pays du Gers The surface as a whole is in the mature stage of erosion (Map 27 A) The Gers River flows northward over a flood plain which has an average width of one kilometer Rising in varying slopes, the valley walls stretch back to mature ridge tops The eastern valley side is steeper than the western one Tributaries to the main stream have eaten back into the original interfluves and have carved out steep-sided masses which project finger-like toward the main valley

On the remnant of the upland surface which extends farthest toward the Gers River there is a large agglomeration, which is the town of Lectoure (Map 27 B, Pl LXXXIII, Fig 3) It comprises 58 per cent of the total population of the commune The remainder is scattered over the whole area, with a notable tendency toward arrangement of houses in closely knit groups All types of surface are used, but fewer houses are on the flood plains than on either the ridge tops or the slopes The pattern of house distribution indicates decreasing density of population with increasing distance from Lectoure, regardless of surface types

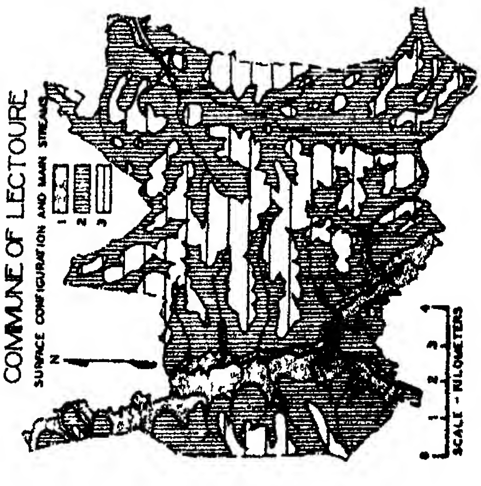
The plateau of Lannemezan stands in considerable contrast to the area of the commune of Lectoure The gently inclined surface of the plateau slopes steeply down to the southeast and the southwest to valleys of Pyrenean streams (Map 28 A) To the north finger-like extensions project between youthful valleys of the rivers which have their sources upon the surface of the plateau It is typically an area of narrow, steep-sided valleys and narrow, flat-topped interfluves

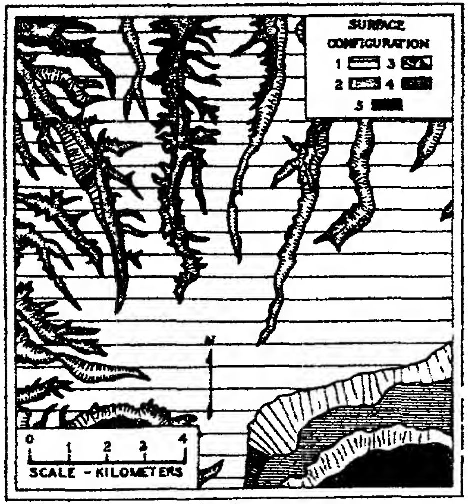
The population is concentrated where the youthful valleys most closely approach one another on the outer fringe of the plateau (Map 28 B) The dissemination of houses is less than in the commune of Lectoure, and the population is almost exclusively confined to the ridge tops Each interfluve bears a loosely arranged agglomera-


COMMUNE OF LECTOURE
DISTRIBUTION OF HOUSES
N
0 1 2 3 4
SCALE - KILOMETERS

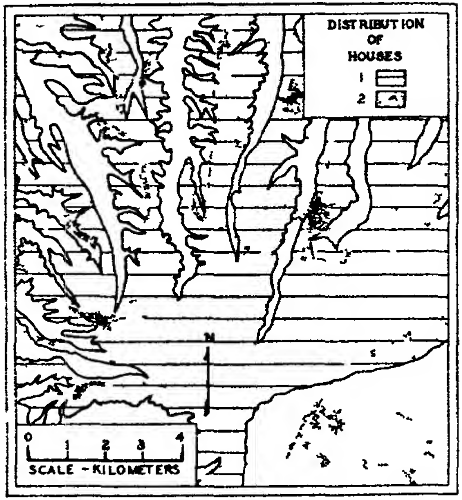
B

3


COMMUNE OF LECTOURE
SURFACE CONFIGURATION AND MAIN STREAMS
1
2
3
N
0 1 2 3 4
SCALE - KILOMETERS



A



B

MAP 28 The Plateau of Lannemezan

A Explanation of symbols 1, undissected plateau surface, 2, flat valley floors, 3 valley sides, 4, terrace of the Neste River, 5, Pyrenean slopes
B Explanation of symbols 1, undissected plateau surface, 2, houses

tion which, in some instances, stretches along the ridge for a distance of two kilometers or more (Pl LXXXV, Fig 2) There are relatively few isolated dwellings

Population agglomerations

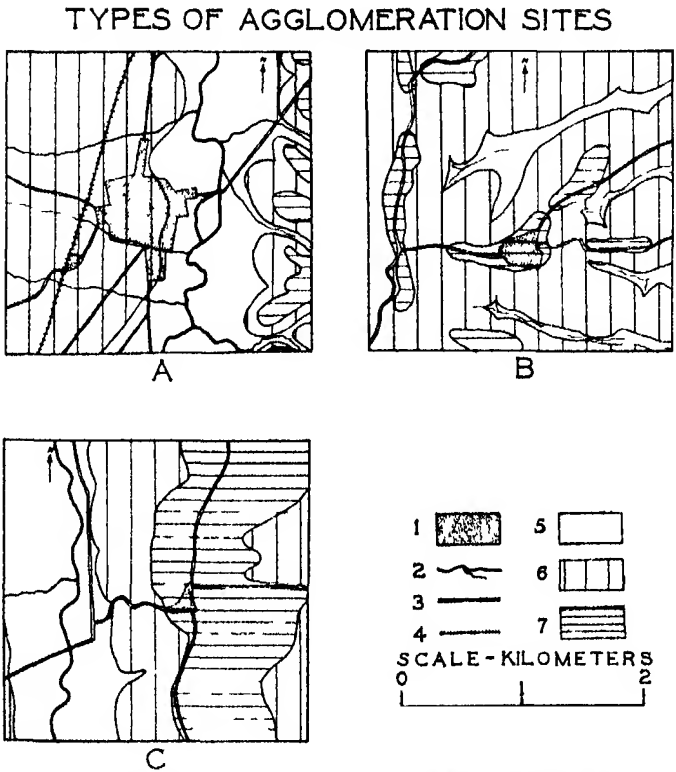
The presence of many agglomerations is the most conspicuous feature of the population distribution Regardless of size, the groups of buildings convey the impression of fitting the setting almost as though they were part of it They are dominantly of limestone in the west and of sun-dried brick in the east In many instances a layer of stucco, made from local clays, covers these materials The color is invariably the yellow-brown of weathered ferrous rock Roofs of reddish tile throughout, except in the southwest, where Pyrenean slate is available near by, are also discolored by weathering A massing of such buildings, whether large or small, results in the same kind of expression on the surface of the land The conspicuousness is, however, more a function of site than of form of these agglomerations

There are three characteristic sites on which these population groupings occur One type of site is the gently sloping side of a main valley at the edge of the present flood plain (Map 29 A) The second type is the hilltop (Map 29 B) The third type is the crest of the steep valley side, where the interfluve is youthful in character (Map 29 C)

The valley sites are occupied in the area of mature valleys and more particularly where the interfluves are mature as well The towns on these sites center on the intersection of two highways, one extends along the valley and the other crosses the valley and the interstream spaces on either side This type of site is not occupied in the southern zone of youthfully dissected surface or for some distance northward into the central zone of mature valleys and youthful interfluves

The hilltop site is most commonly occupied in the northern and eastern maturely dissected portion of the Pays du Gers (Pl LXXXIV, Fig 2) There the agglomeration usually centers about either an old church or a château, and consists mainly of closely packed houses, some of which are contiguous to the church or the château itself The aspect of a walled town is created

The site on the crest of the steep valley side in the areas where the interfluves still retain some of their youthful character is utilized in



MAP 29 Explanation of symbols 1, area covered by agglomerations, 2, streams, 3, roads, 4, railroad, 5, flat valley floor, 6, valley sides, 7, ridge tops

the southern and central surface zones (Pl LXXXIV, Fig 3) Near the northern extremity of the zone of mature valleys and youthful interfluves, where the interfluve edges become more fretted by the erosive action of an increased number of tributary streams, agglomerations are at the ends of the projections of these interfluves toward the main valleys In the south some agglomerations occupy the whole width of the narrow interstream spaces

In the choice of the last two types of site protection seems to have been the guiding principle [39] All the older towns and villages have sites of one or the other of these two types With the advent of comparative stability of government and freedom from invasion,[40] valley sites came to be occupied The increase in completeness of articulation with the rest of France made positions along the main routes more desirable

With increased population in the valley towns many of them have spread out over the present flood plains of the rivers, but in all such instances artificial control of river waters is practiced either by the construction of diversion channels upstream from the town or by building deeper, walled channels along the stream courses within the agglomerations (Pl LXXXII, Fig 2) Many of the groupings on the hilltops or on the crest of the valley sides, where these towns are situated near the major streams, have, with the increased importance of road and rail connections, spread from their original sites down the valley sides (Pl LXXXV, Fig 1) They have even grown across the flood plain in their attempts to overcome the handicaps of the positions imposed upon them by the necessities of another age

The remainder of the population is distributed about the towns and villages in a manner dependent upon the pattern of circulation forms These, in turn, reflect closely the surface configuration Consequently the spread of population is quite evenly radial about the towns and villages in the zone of maturely dissected surface Where youthful surface forms alone are present, the population spread has been confined to the ridge tops The central zone is transitional in terms of population distribution, as it is in terms of surface configuration However, there is no sharp break between the patterns in the various parts of the whole area

CIRCULATION

In the arrangement of all the forms of circulation the relationship to surface configuration is recognizable, though it is more clearly demonstrated in some parts of the region than in others In the south limitations are imposed by the boldness of the relief In the north relief is less hampering to free development, though the limi-

[39] Laurant, Gustave, "Armagnac et pays du Gers," *Rev de Gascogne*, 53d year, New Series, 12 289 1912

[40] *Ibid*, p 300

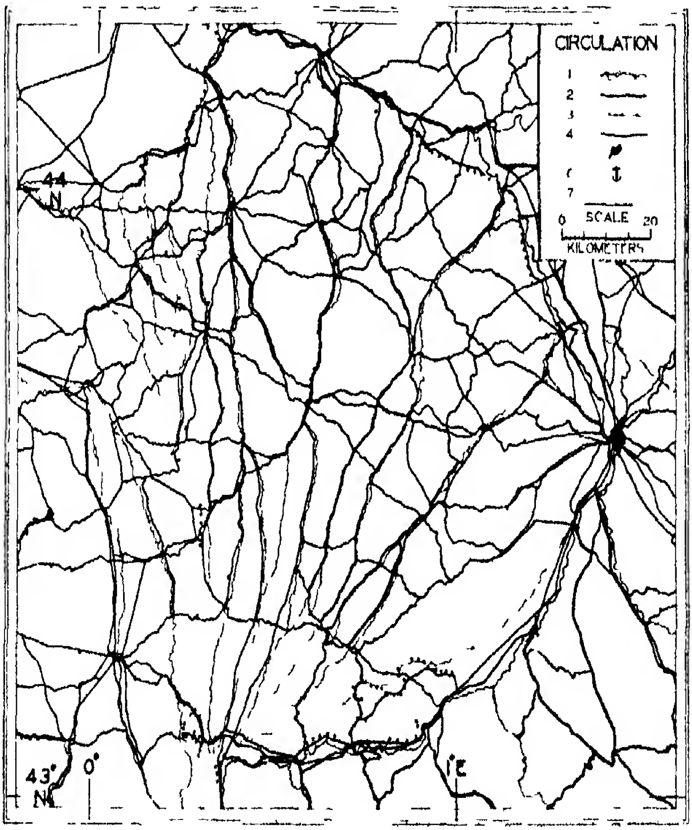
tations are not sufficiently relaxed to allow the divorcement of the pattern of circulation forms from that of surface configuration

Roads

Two classes of roads may be recognized on the basis of conspicuousness in the landscape The hard-surfaced roads, whether they are "Routes Nationales" or "Routes Départementales," are most frequently traveled They are characteristically about five meters in width Along both sides and set back about two meters from the edges there are usually lines of trees (Pl LXXXIV, Fig 1) These draw attention to the roads perhaps even more than do the streams of traffic which flow along them Such highways are the main or the major routes of communication In contrast to them are the minor roads which are unsurfaced Great variety in width and upkeep make them undesirable except as tributaries to the main highways They vary from mere cart tracks or sinuous thin bands of unsodded surface to expanses of sand, clay, or gravel five or six meters wide Usually they are not observable from any considerable distance and, though they may alter the landscape pattern in detail, their function in this respect is completely overshadowed by that of the major roads

In general, the highways diverge radially from a focus on the plateau of Lannemezan (Map 30) One road crosses the plateau from the premontane valley of the Neste on the east to that of the Arros on the west At right angles to it two highways stretch northward in a subparallel plan along the finger-like plateau extensions About fifteen kilometers from the plateau they descend the left valley sides to the level of the present flood plains One follows the valley of the Petite Baïse River to its junction with the Grande Baïse, along which the road continues its northward course The other follows the Gers River They extend along diverging courses in the same position relative to the valley floors as far as the latitude of Auch North of this there are frequent shifts from one valley side to the other, depending upon the position of the streams in their flood plains One road joins the Bordeaux-Toulouse highway in the Garonne Valley at Agen, the other, at Porte Ste Marie

Until the latitude of Auch is reached main east-west roads are infrequent but, in addition to the two mentioned above, many roads diverge northward They follow ridge tops (Pl LXXXVI, Fig 1) or



MAP 30 The Pays du Gers and surrounding area Based on Carte de France à 1 200,000 — 1927 édition Explanation of symbols 1, main rivers, 2, standard-gauge railroads, 3, narrow gauge railroads, 4, main roads, 5, towns with more than 2,000 inhabitants 6, head of navigation on the Baïse River, 7, limit of the Pays du Gers

the edges of the valley floors Frequently roads from tributaries unite with those in the main valleys This upsets the regularity of the radial pattern

North of Auch, where the relief is less marked and the slopes are less abrupt, each large agglomeration of population is the center of a secondary radial pattern which masks the basic one Ridges are more frequently chosen for roads in this section than are the valleys, though all types of surfaces are utilized with considerable ease (Pl LXXXII, Fig 1)

The base from which the present pattern developed is found in a pre-Roman route which connected Aquitain with Aragon across the central Pyrenees [41] This route left the Pyrenees near the apex of the fan, crossed the plateau of Lannemezan, and followed northward along the water parting of the Adour and the Garonne drainage basins Such a route avoided the bridging of streams and the surmounting of steep slopes A portion of it is followed by the present road just to the northwest of the Pays du Gers

More significant in the present pattern are the Roman roads Only four of these have been definitely traced One of them connected Agen on the north with St Bertrand de Comminges on the south [42] This is essentially the route followed by the present road in the valley of the Gers from Agen to Masseube To the south of that place it found its way in zigzag fashion across the intervening valleys to its destination Another highway connected Toulouse and Agen by way of Lectoure [43] The third connected Toulouse and Dax [44] The present road from Toulouse to Auch and on to the northwest follows nearly exactly the trace of this old Roman thoroughfare The fourth was of a later date than the others It connected St Bertrand de Comminges and Dax, crossing the plateau of Lannemezan near the northern limit of its undissected surface [45]

The choice of the particular trajectory which the present road follows across the plateau of Lannemezan is primarily the function of the road which preceded it and of the position of agglomerations of

[41] De Casteran, Paul, "La Lande de Boc," *Rev de Comminges*, 13 246 1898

[42] Laurant, Gustave, "Armagnac et pays du Gers" *Rev de Gascogne*, 54th year, New Series, 13 48–54 1913

[43] *Ibid*

[44] See *Itinéraire d'Antonin* in Desjardin, Ernest, *Géographie historique et administrative de la Gaule romaine* (Hachette, Paris, 1885), Vol IV

[45] Fabre, "Les Landes . . . ," p 260

population on the portion of the plateau surface that extends northward It is not a function of surface differences So it is likewise with the course of the road from the south across the plateau Minor roads are all straight, except those that bend slightly to the south to avoid the headwater ravines of the streams which have their origin on the upland surface

In the zone of asymmetrical valleys and flat-topped interfluves the main roads, with one exception, extend along the grain of the country The one exception is the road which forms a semicircle from Tarbes on the west of the region to St Gaudens on the east Between this road and the plateau the two routes previously mentioned as the skeleton of the whole pattern are the only main-traveled thoroughfares To the north of it nearly every valley and a few of the interfluves are served by well-traveled highways They extend as far northward as the next main east-west road, which is the one that winds its sinuous course from Toulouse through Auch In this zone the ruggedness of the land surface is not great enough to prevent the construction of roads in almost any direction, but ease of communication on a north-south line has emphasized the importance of routes so oriented The minor roads are for the greater part connecting links between the north-south highways, though occasionally they parallel the major ones

To the north of Auch the undulating character of the surface is shown by the fact that the roads are no longer confined to the valleys or to the ridge tops Nearly direct routes between the larger population agglomerations are followed The roads are not laid out along straight lines, with no conformity to surface At the same time they are much less closely controlled by it than they are to the south of Auch In many instances the hamlets and villages are not located on the main highways, but are connected to them by short spurs In a few places this indicates a local difficulty of surface, but more frequently it is a reflection of the character of the agglomeration itself Many of them are older than the road system and consequently are too compact to allow the unimpeded movement of the traffic that passes over the main highways The minor roads form a very complete connecting network between the main roads They extend over all types of surface and link the whole population to the larger centers

Auch, which is located on the border between the zone of roads

closely controlled by surface features and the zone in which there is little control by surface, forms the center of an octopus-like pattern of main highways (Map 30) At Auch the north-south and the east-west Roman roads crossed, and, though the town does not owe its origin to that fact,[46] the road intersection has undoubtedly been an important factor in the development of that town as a center toward which the whole region is focused Three main highways have been added to the original ones from Auch One of these branches from the highway leading westward crosses the upland to the northwest and descends a tributary valley to the Baïse, where it joins a main north-south highway The second of these additional roads branches to the southwest, follows up a tributary valley for about five kilometers, and makes its rather tortuous way across five interfluves to the plain of the Adour The third supplementary road extends directly southeast from the city across valley and interfluve alike to Lombez in the valley of the Save All these additions are relatively recent in construction and are dominantly political in importance Auch is the *préfecture* of the Department of Gers Condom, Mirande, and Lombez are *sous-préfectures* The three roads link these latter towns with Auch and make it a focus for the whole region

The basic pattern of highways is radial from the plateau of Lannemezan and, in its southerly portion, is limited in its digression from that form by the surface configuration To the north the superimposition of other radial patterns, the most important of which is that about Auch, indicates a very weak control by surface Purely cultural forces have subtracted from the effective natural focus position of the plateau of Lannemezan and have substituted the town of Auch in its place Thus there is close integration within the region as well as direct articulation with the road systems of all surrounding regions, with the exception of the Landes

Railroads

The railroad pattern is far less complex than that of the roads, though the rôle which the railroads play in emphasizing the focal position of Auch is great Not only is this function well performed,

[46] Guilbert, *op cit*, II 210 Auch was established previous to the Roman occupance of this region

but the railroads link Auch and, through it, the whole region to the densely peopled urban centers of France

Main railroad lines extend in four directions from Auch as a center (Map 30) At the present time[47] a fifth main line is being constructed southward from Auch along the valley of the Gers It has been under construction for a long time, and the original intention was to continue it across the plateau of Lannemezan to the valley of the upper Neste A southward extension was to follow along the old trans-Pyrenean route In event of the completion of this project it is suggested that the focus would shift and that the plateau, as represented by the town of Lannemezan, from which a spur line extends southward a short distance at present, would become the nucleus of the occupance of the region,[48] as it is of the setting

Narrow-gauge railroads extend toward the center of the Pays du Gers from the north, east, and west They serve the sections which are most remote from the main lines that cross the country, but they are not integrated with the essential pattern of railroads within the Pays du Gers

Waterways

There is one other connecting link with the outside world, though it is of little importance as a bond within the area The Baïse has been canalized as far as Condom (Pl LXXXII, Fig 2), which is a center of the armagnac[49] trade Small barges ply between Condom and Bordeau along the Baïse River, the Canal lateral de la Garonne, and the Gironde estuary This route is an outlet for a special commodity and is rarely used for any other purpose than the shipping of that commodity

THE USE OF THE LAND

Close integration with the setting is shown in the forms of circulation throughout the Pays du Gers The pattern of circulation forms is the framework upon which the population is distributed

[47] The summer of 1930

[48] De Casteran, *op cit*, pp 246–247

[49] *Armagnac* is the name given to brandy which is distilled from the white wines of Bas Armagnac, Tenareze, and Haut Armagnac. Tenareze and Bas Armagnac are *pays* lying outside the Pays du Gers and to the west of Haut Armagnac, as the northwestern part of the Pays du Gers is called See De Cassagnac, Paul, *Les Vins de France* (Hachette, Paris, 1927), pp 192–193 See also Shand, P Morton, *A Book of French Wines* (Knopf, London, 1928), p 238

These relationships suggest a regional unity The nature of the population furthers the idea of unity within the region as well as of contrast with surrounding portions of the Aquitain Basin It is the use of the land, however, which binds the elements of the setting, of population, and of circulation into a whole which is the landscape of the Central Pyrenean Piedmont of France

The agriculture of the Pays du Gers

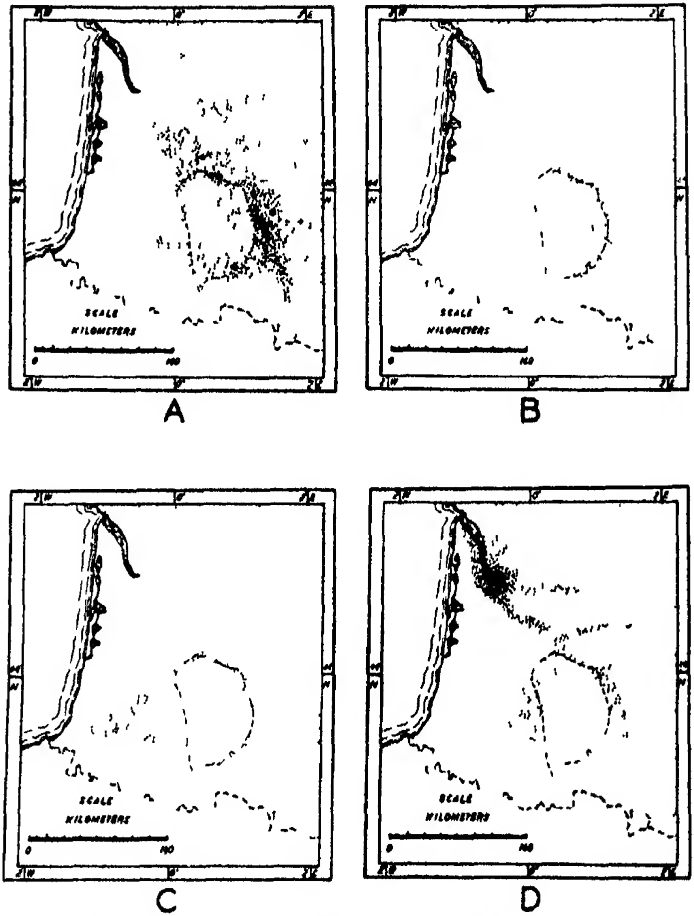
Within the Pays du Gers there is variation of detail, yet the basic combination of rural forms is the same throughout Most of the land is cleared or has always existed without forest cover, and a large share of this is in crops The portion which is not so used is taken up for the greater part as pasture land Very little may be truly classed as waste Sixty-two per cent [50] of the land is arable, eleven per cent is natural grassland, eight per cent is heath, moor, or brush land, seven per cent is wood-covered, and six per cent is in pasture or meadow The remaining six per cent of the area is occupied by buildings, roads, and waste land

Somewhat more than half the arable land is cropped The dominant crop is wheat, and it is found more or less evenly distributed throughout It occupies about twenty-seven per cent of the arable land Its closest competitor, areally, is the vine, which extends over thirteen per cent of the arable area Two other grain crops are important, oats on seven per cent of the land and maize on four per cent The remainder is used for such items as garden crops, fruit, and, occasionally, rye Each year a considerable amount of land is allowed to lie fallow or is used as rotation pasture

In the animal industries cattle production for beef is distinctly the most important and is approached only by hog and poultry raising In the amount of land used the animal industries as a whole are important throughout, for it is only in terms of an integrated system of crop raising and animal production that the rural occupance of the area is expressed

Though wheat is the major crop almost throughout, the secondary crops vary in importance in the different parts of the Pays du Gers (Map 31, A–D) The vine is distinctly more important along the northern fringe and in the Baïse lowland than elsewhere Maize is of

[50] All the statistics mentioned in this section of the paper are from *Statistique agricole annuelle, 1930* (Impr Nationale, Paris, 1932)



MAP 31 Distribution of crops in southwestern France A, wheat, B, oats, C, maize, D, vine One dot equals 250 hectares Dashed line indicates limit of the Pays du Gers

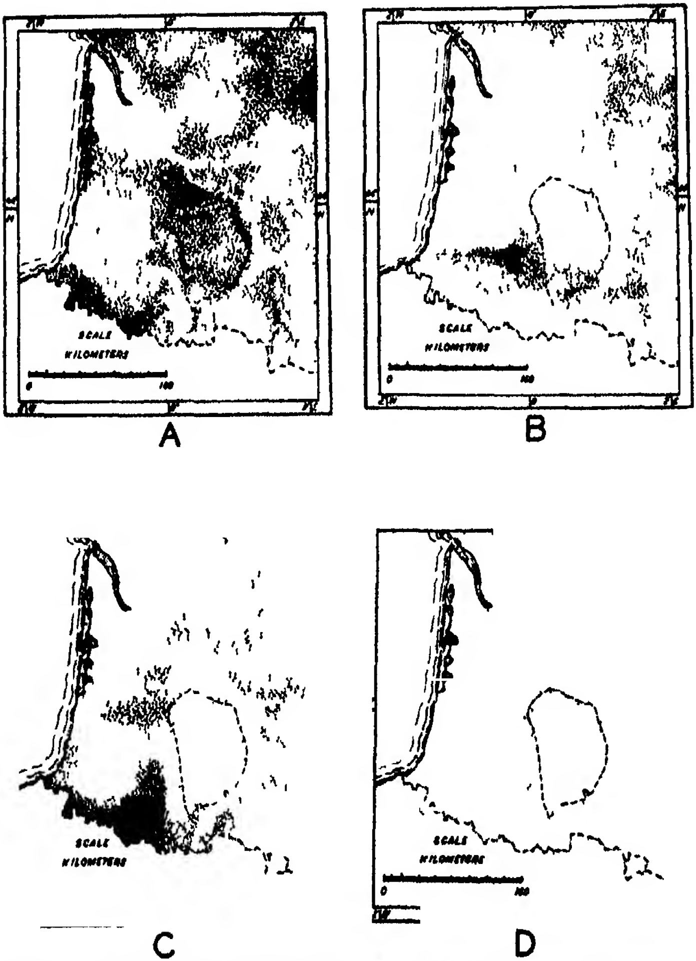
greater importance in the southwestern part and along the Garonne Valley fringes than it is throughout most of the rest of the region This does not hold true locally, however Oats are clearly the dominant secondary crop in the eastern half of the region The particular use of the land in any one year may show an increase in any one of the secondary crops at the expense of the others in any portion of the Pays du Gers, but the average of conditions is that stated above

The same kind of variation is to be noted in the distribution of the animals (Map 32, A-D) Cattle are plentiful over all the land, but there are fewer as the plateau of Lannemezan is approached On the other hand, the numbers of sheep and hogs increase in that direction Sheep are not very numerous except in that portion nearest the Landes and on the plateau of Lannemezan, whereas hogs are present in the greatest numbers in the southern one third of the region

The variations of the crop and animal combinations in quantity, though not in quality of types represented, reflect the characters of the surrounding regions The Pays du Gers is an area of blending of the specialized forms of agricultural and pastoral pursuits found throughout the whole of the Aquitain Basin

Land-use patterns

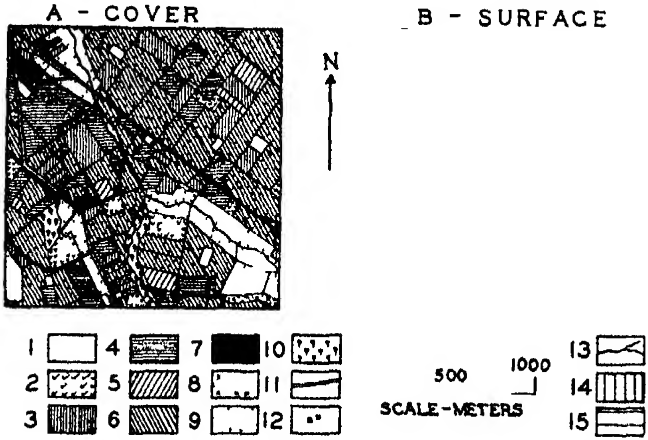
The patterns of land use fuse the differences within the Pays du Gers into a whole which emphasizes the setting and the distribution of people through it To the north the waves of hilly land present the aspect of a huge park stretching as far as can be seen (Pl LXXXII, Fig 1) The surface is dotted with villages and hamlets and gives the appearance of being much more wooded than is actually the fact Intermingled with the trees and clustered about the dwellings and along the roads the fields form a checkerboard with varying color indicating the crop, pasture, and woodland mosaic (Map 33, A B) The fields are rectangular, and many are outlined by hedgerows from which the poplars stand up as thin spires The major streams are definitely traced by the lines of willows, alders, and poplars along their banks The roads, too, stand out because of the trees which mark their courses Most notable over this whole scene is the concentration of pasture (Pl LXXXVI, Fig 2) and hay land in the valley bottoms (Pl LXXXIII, Fig 3) and the occurrence of cropped land on the hillsides Though the checkerboard arrangement persists



MAP 32 Distribution of animals in southwestern France A, cattle, B, hogs, C, sheep, D, horses. One dot equals 250 head Dashed line indicates limit of the Pays du Gers

over valley and hill alike, there is little regularity in orientation In some places the fields bear a close relationship to the population agglomerations In others they are oriented with respect to the roads Yet, over all, the exact demarcation of field lines is the dominant impression

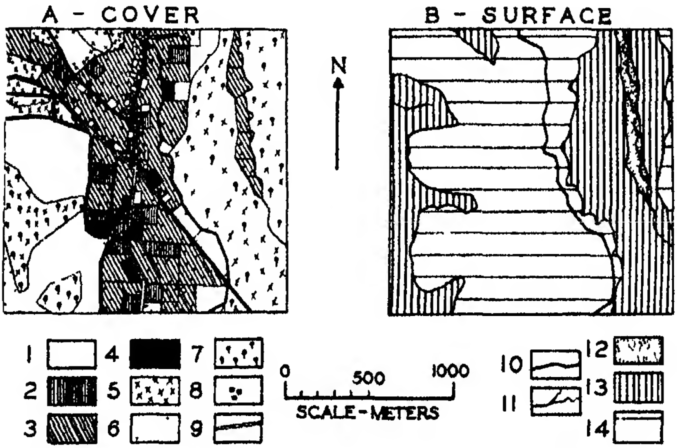
Greater conformity to the pattern of surface features is to be noted farther to the south (Map 34, A-B) With increasing asym-



MAP 33 A small area near the northeastern limit of the Pays du Gers Explanation of symbols 1, garden, 2, vineyard, 3, maize, 4, wheat, 5, oats, 6, land from which hay is cut, 7, clover, 8, brush, 9, pasture, 10, woods, 11, roads, 12, houses and barns, 13, streams, 14, valley sides, 15, ridge tops

metry of the valleys in that direction there is an increased amount of land unsuited for crops or even for pasture For this reason more of the land is wooded or covered with brush (Pl LXXXVI, Fig 3) The valley bottoms retain their function as pasture land or meadow, but the crop land is very definitely arranged in conformity with the surfaces of gentle slope The western valley sides and the flat-topped interfluve remnants are the sites of most of the cultivated land There results a striplike pattern oriented in a roughly north south direction in which cultivated land is nearly paralleled by pasture and meadow, and that in turn by woodland and brush land

Beyond the zone in which the valleys are flat-floored the same type of arrangement is found, except that less of the valley bottom is used for pasture and none of the valley sides are used for cropping other than of the garden type A few fields nestle in the tree-covered valleys, but these are either pasture or hay lot (Pl LXXXIII, Fig 1) Crop cultivation is limited to the finger-like projections of the dissected edge of the plateau of Lannemezan



MAP 34 A small area on one of the northward projections of the dissected edge of the plateau of Lannemezan Explanation of symbols 1, garden, 2, maize, 3, land from which hay is cut, 4, potatoes, 5, brush, 6, pasture, 7, woods, 8, houses and barns, 9, roads, 10, canal, 11, streams, 12, flat valley floors, 13, valley sides, 14, ridge top

The surface of the plateau is cultivated only along its northern edge or around the few population agglomerations which exist upon it The surface is not divided into fields, and little breaks the monotony of the continuous stretch of scrubby vegetation except here and there some small forest remnant (Pl LXXXIII, Fig 2) Sheep grazing is unrestricted in its extent upon this land, but no fenced pasture exists

The general pattern of land use in the Pays du Gers reflects very completely the surface configuration In detail, however, this is often only indirectly so The field patterns are locally oriented with respect

to the roads and, through them, to conditions of surface In sections where the presence of a population group seems to be more immediately the effective agent of arrangement, that very fact links the pattern to that of surface either directly or through the element of the road pattern The earliest settlements of the Pays du Gers were relatively isolated communities and, for a long period of time, they have been of a self-sufficient type In many places they have opposed the advance in means of communication which would remove the necessity of that self-sufficiency The early groupings of such communities for protection brought about a pattern of land use which still persists in a fragmentary way

Grouped about the church or château, the houses capped the top of a prominent hill set in the midst of the forest-covered land Clearings in the wider valley bottoms may have broken the extent of forest Gradually the land around the settlement was cleared and the fields for immediate necessities were laid out As the clearing of the land spread down the slopes to join with the natural grasslands of the valleys, more and more land was opened to cultivation Fields were larger since there was a greater amount of land for each individual as the circle of cleared land spread In the landscape of the present the concentric pattern, in which increasing size of field accompanies increasing distance from the settlement, is found to be present residually in the maturely dissected portion of the Pays du Gers (Pl LXXXIV, Fig 2) Associated with this pattern there is usually a specific zoning of crops Encircling the buildings are the smallest fields, which are used as gardens or vineyards Around them in the larger fields are the grain crops And, farthest removed, are the lands given over to pasture This is not invariably the arrangement, for frequently the fields close to the hamlet or village are used for pasture Around the larger agglomerations this pattern, if it existed originally, has been considerably modified or destroyed by the gradual extension of the built-up area With the increase in importance of roads and with the decrease in self-sufficiency of small parts of the Pays du Gers, a new group of determining factors has arisen

Where the road has become more significant than the population agglomeration and where settlement has spread along the roads either as small agglomerations or as isolated houses, the road itself is the axis of the pattern Small fields line the highway on both

sides Back from the roads the size of the fields usually increases Crops are grown in those nearest the roads while those farthest removed are in pasture

The year in the Pays du Gers

Though the clear-cut decline of activity within the severe winter lands or within the lands of seasonal drought is lacking in the Pays du Gers, there is a very definite rhythm of intensity of life through the year There are certain periods in which each kind of activity is at its height and other periods when it is practically dormant The climatic position of the region is responsible for this rhythm, and it is to varying climatic factors within the region that most of the modification of this rhythm is related

In the vicinity of Auch January and February are the months of least activity The temperatures of this period of the year are sufficiently low to make undesirable the working of the land, but they are not low enough to force the removal of the animals from pasture This condition leaves little that can be done about the farm other than the repair of implements The lack of work results in an increased interest in the fairs and markets of the towns and villages The Gersois peasant dearly loves a gathering of any sort,[81] and he makes the best of this opportunity The roads are the living parts of the landscape It seems as though every person in the land is on his way to or from town

With the coming of March there is a change This is the beginning of the season of heaviest rains, and preparations are made to prevent damage to property The increased precipitation causes a rise in river level, which is continued through April and May Floods may cover all the lower land of the valleys and may endanger the lives of the animals if they are left in the customary pastures They are brought to the farm and, if no neighboring land is suitable for pasture, they are fed and closely cared for Then, too, the land is plowed before the heavier rains fall Otherwise, the fields, particularly those on clayey soil, are quaggy and impossible to plow The towns are forgotten From the first noticeable rise of temperature in March the preparation of the land for crops is the sole end in view for the larger part of the population. In late April or early May oats are planted and shortly thereafter, maize is sown, and attention is given

[81] Caziot, *op cit*, p 331

to vineyards Wheat, planted the winter before, brings a green color to the whole land

Continued farm activity accompanies the marked beginning of summer in late June There is no further need of keeping the animals close to the farm for feeding They are turned loose in pastures which have been refreshed by the short period of little use The crops are well started by the time the rain begins to decrease in amount With the coming of the dry, hot period of July and August the harvests begin The wheat has ripened and it is cut and threshed Throughout the region the constant coughing of the gasoline engines of wheat-threshing machines is to be heard Some of the farmers still use the old method of driving the oxen round and round on a hardened earth threshing floor and then winnowing the grain in the hot blasts of the *vent d'autan*,[52] which is at its strongest at this time of year

The wheat harvest lasts but a relatively short time There is a hiatus in the farm work and, with almost clocklike precision, the towns take on the exaggerated importance of the January-February season The land with its ripening crops is slighted It is almost devoid of human beings

Late August and September witness another reversal In rapid succession come the grape, oat, maize, and fruit harvests Everyone is pressed into service The country hums and the villages and towns are silent

Immediately the harvests are done the land is prepared and sown in wheat The vineyards are looked after, pruned and sprayed, and wine is made When November comes and the pressing farm work is done, there begins the manufacture of the one specialty of the region The wine is distilled and made into armagnac With the completion of this work the year is rounded out, and there comes again the season of increased social life for the whole area

In all directions from the vicinity of Auch this rhythm of life is varied to a minor degree The variance is primarily a recognizable function of the setting, although it is in part caused by differences in the distribution of population To the south and west there is a greater amount of rainfall which results in the changed emphasis of

[52] The *vents d'autan* are Mediterranean in origin See de Martonne, E, "Note préliminaire sur le vent d'autan," *Bull Soc languedocienne de géog*, 30 100–114 1907, and *idem*, "Contribution à l'étude du vent d'autan (deuxième note)," *ibid*, 32 135–157 1909

utilization of the land Likewise toward the south the winters are more severe and the summers are hotter and drier The winter is sufficiently severe to necessitate the ration feeding of animals This one item, coupled with a different distribution of population, decreases the importance of town gatherings in the winter life of the inhabitants They are more completely tied to the farm The climatic differences also make impossible the cultivation of some of the same crops The increase in the amount of rainfall is particularly injurious to wheat while the lowered temperature of winter makes the vine a less satisfactory crop Nevertheless, there is discernible the same type of rhythm of life as that near Auch The movement of sheep to pasture on the plateau of Lannemezan during the summer months, though of greater magnitude, is essentially the same as the movement of cattle to new pasturage during summer in the center of the Pays du Gers

CONCLUSION

The rural scene is the only important one and, though it varies from part to part of the region, it is only the result of necessity of detailed adjustment that brings about any difference The same kind of people live in the same way in all sections That way is distinct from those of adjoining areas The way of living in the Pays du Gers is not like the agricultural life of the Garonne lowland, in which fruit cultivation is of primary importance It is not like the corn-hog-vine economy of the Adour drainage basin to the west, nor is it like the Landes where pastoral life predominates Likewise the pastoral life of the Pyrenean slopes contrasts sharply with it Within the Pays du Gers all these various economies are blended to form a rural occupance of the type which lays equal stress upon agriculture and the animal industries Specialization in commercial production is secondary to sustenance farming

Thus it is that a small portion of the earth's surface with an associated group of natural phenomena stands out as distinct from the surrounding lands And upon this small area the items of human occupance are arranged in such a way as to emphasize its individuality The natural phenomena focus on the small remnant of the plateau of Lannemezan The occupance phenomena focus upon Auch The two have been inseparably welded through time to form the present phase of ever-changing landscape of the Central Pyrenean Piedmont of France

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PLATE LXXXI

FIG. 1. The plateau of Lannemezan looking northward toward the dissected and forested edge.

One of the V-shaped valleys at the northern edge of the plateau of Lannemezan.

FIG. 3. The middle valley of the Save River in August. The present stream is cutting below the level of the flat valley floor.

PLATE LXXXII

FIG. 1. The gently undulating surface of the part of the Pays du Ger

FIG. 2. The canalized Baïse River at Condom looking

FIG. 3. Tree and brush growth along one of the major streams

PLATE LXXXIII

FIG. 1. The wooded eastern side of the upper valley of the Baïse River. The extent of the grassland in the valley bottom is very limited, and there are only a few clearings.

FIG. 2. Pastured woodland near the source of the Baïse River on the plateau of Lannemezan.

FIG. 3. The town of L

PLATE LXXXIV

FIG. 1. A *route nationale* in the northwestern part of the Pays du Gers.

FIG. 2. Flamarens, a hilltop village in the [illegible] part of the Pays du Gers.

FIG. 3. Puymaurin, a town on the crest of the steep valley side in the southern part of the Pays du Gers.

Fig. 1

Fig. 2

Fig. 1. The town of A[illegible]. The cathedral [illegible] mark the [illegible] spread down the valley [illegible]

Fig. 2. The town of [illegible]

PLATE LXXXVI

Fig. 1. The row of trees along the ridge in the background lines a main highway. The town is Gimont, which is about twenty-five kilometers east of Auch.

Fig. 2. Pasture on the flat valley floor.

Fig. 3. Cleared valley floor and wooded coste

NOTES ON THE ASSEMBLY OF AIRPLANE PHOTOGRAPHIC MOSAICS

HAROLD UNDERHILL

THE World War brought about the demand for and the initial development of photography from airplanes for purposes of military strategy and mapping. From that period to the present date various interested civilian groups organized for profit have sought to apply to our civil needs the knowledge gained by their war experience. Greatly improved cameras, the new extremely sensitive films, and better airplanes make possible the excellent air photography of today. The outstanding application of airplane photography to our civil needs is that of mapping.

When base data, such as lakes, streams, roads, cultivated lands, cities, and villages, are desired in the most minute detail, the air photograph is superior to ordinary maps. Larger areas than can be photographed upon a single print are mapped by assembling into a unit the overlapping photographs covering the desired area. Such a composite photograph is called a mosaic.

Here in Michigan we have found it convenient, through coöperation with the United States Geological Survey, to secure the services of trained United States Army pilots and photographers for the purpose of photographing from the air many of our hitherto unmapped counties. This work is being done in connection with our regular state program of topographic mapping.

Since our first county was photographed from the air in 1929 it has been the good fortune of the writer to be in charge of the filing of these photographs for the Geological Survey Division. About February, 1931, the Forest Fire Division, seeing the value of this new type of map as an aid in fighting forest fires, began the assembly of township mosaics, which now number 304 and picture approximately ten thousand square miles of territory.

During the past three years the methods used in the assembly of our mosaics have developed step by step, until a standard and

an efficient routine has been attained Future work along this line will yield new material for discussion However, it is the purpose of the writer to record for the benefit of the novice our present procedure that he may profit by our experience Conventional methods of mosaic assembly could not be used, for two reasons first, lack of control, since our photographs covered unmapped areas, second, the prohibitive cost of scale changes by ratio printing, since by agreement the United States Army retains for a stated period the negatives from which our prints are made

Our standard air photograph is a contact print made with a negative from a single-lens camera that uses a roll film 10 inches wide and 75 feet long A contact print measures about 7 by 9 inches and is usually printed upon glossy single-weight paper Some cameras are so equipped that a small number panel is photographed along the center of one side of each photograph In the top of the center of this small panel is reproduced a rotary altimeter dial that records the altitude of the ship at the instant of exposure Below the altimeter is the number of the photograph, shown on a small dial similar to the mileage dial of an automobile speedometer To the right of this center group there are a circular bubble, to indicate the tilt of the camera, if any, and the face of a small clock giving the time of exposure On the left side is a blank in which may be written for reproduction the date of flight and the name of the location of the job flown

Few prints in our files, however, exhibit easily readable information in this number panel The majority of them have been blacked out and the negatives numbered with ink in the laboratory after trial sets of prints have been laid out This insures prints of a broken-flight strip getting consecutive numbers whether or not the entire strip was photographed on a single flight Adjacent photographs overlap each other considerably, some contracts call for as much as 60 per cent side overlap and 50 per cent end overlap This is necessary because the outer margins of a photograph are not on the same scale as the center portion, which was immediately below the camera at the time of exposure Variations from normal in the position of the ship and the camera at the moment of exposure cause scale distortions in the photograph which may be so bad as to render it worthless This type of wing-tilt off-scale print is difficult to detect in photographs of wilderness country, but when it occurs in those of

farming regions with well-blocked-out road systems the opposite sides of a section will be shortened or elongated along the axis of tilt

Commonly the most troublesome type of off-scale photograph is caused by variation in altitude of the ship Weather changes often affect the barometric altimeter during a flight, or a change of ground elevation under the plane may be the disturbing factor Either may cause a perfectly flown ship to produce off-scale photographs

The happiest results, so far as photograph mosaic assembly is concerned, are obtained when the area to be flown is so small that it can be photographed on a single hop A careful check of barometric pressure before each flight is the rule on large jobs and should produce uniformity of scale from day to day However, the novice must be tolerant with the pilot and the photographer, who, when aloft, are two of the busiest men above earth, and should remember that as a matter of fact perfect scale photographs are generally sales talk

Fully equipped laboratories have ratio printing machines by means of which both the altitude and the wing-tilt varieties of off-scale photographs may be corrected Such a machine is essentially a vertical enlargement printer whose copy board may be tilted out of the horizontal plane to correct any tilt errors present in the negative Prints made in contact with the negative are always more brilliant in appearance and show finer detail than prints made in such a restitutional printer or other enlargement camera

There would seem to be every reason to invent and perfect an improved altitude meter that would give the pilot actual altitude above ground instead of altitude above sea level

The altitude at which a pilot must fly to produce photographs of a given scale is easily arrived at Given the focal length of the camera lens in inches and the desired ground distance to be represented by one inch on the photograph, a simple ratio provides the altitude For example, if one has to determine the altitude necessary for a 12-inch focal length lens to produce photographs on a scale of 1 inch to 1000 feet on the ground, $\frac{1 \text{ inch}}{1{,}000 \text{ feet}} = \frac{12 \text{ inches}}{12{,}000 \text{ feet}}$ Again, on a scale of 1 inch to 400 feet on the ground, if one uses an 8-inch lens $\frac{1 \text{ inch}}{400 \text{ feet}} = \frac{8 \text{ inches}}{3{,}200 \text{ feet}}$

A flight across a given area produces a series of overlapping photographs called a strip. Adjacent strips overlap and are generally flown in opposite directions, with the pilot usually making a nearly vertical bank at the end of the flight and reversing his direction for the return trip while the photographer snaps one or more shots with the camera shutter closed to indicate the end of a strip on the roll film.

In the laboratory, after the first set of prints has been laid out roughly to determine whether any gaps or "missouts" exist, a flight map or key map is prepared for the convenience of the customer, who receives it with his copies of the photographs. This flight map usually shows the beginning and the end of each separate flight by means of two rectangles inclosing the exact areas on the map covered by the first and last photographs of the flight. Each rectangle is given the number of the photograph it represents. The locations of intermediate photographs are generally omitted. However, the course of flight is sometimes shown by a line. If this map is too large for convenient filing it may be reduced in photostatic copies, on which adjacent strips are shaded with contrasting colored crayons and large numbers are inked in for visibility. Photographs may be located accurately and quickly from flight maps colored and renumbered in this manner.

A brief description of other and more important items of equipment used in the assembly of our air-photograph mosaics will be found in the Appendix to this paper.

The scale of the mosaic is probably the first consideration to come up after it has been decided to make an aërial photographic survey of an area. The use to which the map is to be put will govern the size of objects upon the photograph. "Scale" is the ratio of unit distance on the photograph to unit distance on the ground, i.e. if one foot of photograph portrays 12,000 feet of ground, the scale is represented by the fraction $\frac{1}{12,000}$. More commonly the scale is expressed by a statement of the relation of one inch of photograph to the actual ground distance it represents, such as 800 or 1,000 feet to the inch. It is also expressed in inches per mile. The following are different ways of expressing the scale of a single air photograph (all mean the same): $\frac{1}{12,000}$, 1,000 feet to the inch, 5.28 inches to the mile. This scale is standard in our photographs, namely, $\frac{1}{12,000}$. One county was flown on a $\frac{1}{20,000}$ scale, and it has been laid up in township mosaics, but the results do not compare with other

areas mapped on the former scale, either for visible detail or for general appearance.

If the area to be mapped is large, the size of the individual mosaics is governed by the scale of the prints and the available sizes of mount. At 1,000 feet to the inch, our mosaic of a standard township, six miles each way, measures about 36 by 40 inches over all. This size is amply large for convenient handling and filing. We found the 24-inch mosaic from our one small-scale county a pleasant variation from the larger standard size. See Plate LXXXVII for this scale comparison.

The air photographs of a county to be assembled are put into plainly marked envelopes by flight strips and arranged in their overlapping order across the county. They are then deposited in a file for safe storage. Envelopes containing photographs of the township to be assembled are first removed from the file and arranged in a row on the back table in their proper order. The proper starting point is, of course, that place at which the location of the first few prints is established without doubt. Generally one side of the township is bounded by a well-known and mapped feature, cultural or natural, such as road, lake, stream, or timber-cutting line. In the absence of such information we must use the General Land Office plats for township-corner locations.

After the selection of the starting point the first print is fastened to the assembly board by four staples, without trimming, in a location that allows ample room for the complete assembly of the township. The mosaic is developed most naturally by strips across the board from the starting point. The direction of these strips may be vertical, horizontal, or diagonal, depending upon the direction in which the area was flown when photographed.

Assuming that the first print was laid in the upper left-hand corner of the board and also that the flights were made in an east-west direction, the first strip is laid from left to right across the top of the township. The second strip starts immediately below, overlapping upon the first print laid, and progresses from left to right, overlapping and matching the first strip. In this manner the entire township is developed, provided, of course, that the scale of succeeding strips is constant. Differences of the scale in two prints of adjacent strips may be too small to be noticed when regarded as individuals. However, small errors accumulate in the width of a

township until the total is decidedly too great Usable mosaics have been laid within which adjacent strips have differed in length by as much as one and one-half inches Such an error is uncommon, however, and the assembler is rarely called upon to deal with errors totaling more than one inch across a township All the resourcefulness of the workman is demanded when adjusting and fitting off-scale prints

Sometimes, owing to off-scale photographs, it may seem impossible to complete the assembly of an area by the simple strip-after-strip method just described In this case the quickest way out will probably be *to remove the prints from the board by strips and stack* them in orderly piles upon the back table Starting out anew, the operator staples two or three prints in the first strip, as before Next, he places the first one or two prints of the second strip and then the first one of the third strip This method builds two adjacent sides of a township simultaneously, controlling the included corner angle by its triangular or fan-shaped development

Another system of dry assembly which is more difficult to handle is the radial development which begins at the center of the board and grows from this point in all directions This system is favored by some, but it is not so simple and, therefore, is less desirable than the strip or the corner method, and has been used in but one township mosaic assembly

It is advisable to show only the center portion of any print because the edges are always more or less distorted and out of scale Removal of the overlapping edges of successive prints entails trimming, probably the most important factor in a good assembly In general, from the standpoint of minimum distortion, one half of any overlap should be removed Any deviation from this "one-half" rule makes visible the undesirable distorted edge of the top or bottom photograph in question It is seldom, however, that this rule may be applied literally, since the nature of the country shown on the photographs actually makes the overlap desirable or undesirable Wooded country with few trails, streams, and such features is best torn by a wavy line, whereas cuts through cultivated fields are better straight A straight cut across a print is more noticeable than a series of straight cuts connected by occasional offsets (for instance, cultivated land with offset sideways through a wood lot)

The road system of a mosaic is a most prominent feature, and cuts

should be made well back of farm buildings if they are to receive the minimum of attention Joints too close to roads or down their center may shrink upon drying and cause a double road This cannot occur if roads paralleling a cut are trimmed off the overlaps

Advantage must be taken of every feature on the photograph that will help conceal a cut Wherever possible one should avoid joints through small lakes or other features such as wet marshes The reflections of light from water surfaces cause a surprising change in the shade of lakes upon adjacent photographs In fact, a lake is apt to be white in one and black in the next The darker water areas are the best ones to show, since white water is often confused with sand or marl by the novice Light reflections from water often work to our advantage in disclosing the course of small streams otherwise hidden by forest canopy

Because land values are high in cities and because of difficulty in matching prints over such an area, these photographs are left intact when possible Since errors of assembly occur at the joints, any valuable land, such as village, golf course, lake front, road front, or subdivision properties, is better left uncut if possible

When there is need to cut a print, it is laid upon the trimming board, and the exact path of the proposed tear is cut lightly through the emulsion with an even pressure of the penknife point The undesired part of the photograph is so placed as to overhang the edge of the trimming board The tear is accomplished by pressing the scrap downward and forward away from the operator When this is properly done the tear will start in the photograph and follow the knife cut across it as the hand grasping the scrap piece moves away from the operator After the tear, the scrap should display a white fringe of beveled paper from one eighth to one fourth of an inch wide along the full length of the tear If this evidence of proper feather edge upon the photograph is lacking at any point the desired result must be obtained by inverting the photograph and beveling with the penknife where necessary A spiral shaving of paper indicates proficiency here Scraping with a razor blade or finishing with fine sandpaper is recommended by some to insure a more nearly perfect feather edge In practice, however, the average torn edge, beveled, if necessary, with the knife along the edge of the trimming board, is sufficiently thin to give good camera copies

The pair of small holes caused by fastening with paper-stitcher staples should be made, if possible, under an overlapping photograph They are not so big, however, that they will be noticeable from a short distance, should it be necessary to make them where they will occur upon the finished mosaic A staple in each of three hidden corners is the rule in fastening a print upon the dry assembly board If insufficiently stapled, the photographs may curl badly overnight, or slip out of position

A careful check of the finished dry assembly is essential to detect errors in alignment of straight railroads, highways, power lines, and other features, and poor matching of prints It is sometimes necessary to pull photographs of a short strip apart somewhat The check of the final dry assembly should bring out any too noticeable cases of "twins" from this source "Twin" is a laboratory term for an object such as an isolated tree or farm building that, owing to separation of prints at a joint, is allowed to appear in duplicate As a rule, judicious trimming will remedy a too obvious case of twinning

If the township is shown to be of regular dimensions upon the best available maps of the area, the mosaic will probably be square when completed Correct tilting of the film in the camera at the time of copying often produces a square copy from an off-size or distorted original If this hint is understood at the time of assembly, much detail may be preserved in the longer strips that would ordinarily be telescoped in an attempt to square up the original The experience of our field men who map soils and cover directly upon mosaic copies has been that it is better to sacrifice the scale of a mosaic, if necessary in order that no country be lost by compression of a large-scale strip "Twins" are evident, but lost areas are not self-explanatory to the mosaic reader

Dry assemblies are often torn apart and reassembled several times before the best possible arrangement is found This branch of the work is by far the most important step in the making of a mosaic, and it should not be hurried All but the smallest scraps of photographs used are carefully put away for possible future use

After completing the dry assembly the big question is whether or not we shall be able to reassemble the prints with mucilage, preserving their original arrangement Our present transfer system has worked 100 per cent efficiently since its adoption The first method we used for this transfer of photograph location consisted in tracing

the roads, lakes, and prominent features visible through tracing paper and transferring these base data to the mount by means of carbon paper The photographs were then mounted over this network However, though this method served, we were forced to find something better when the country changed from farm lands with well-developed road systems to wilderness, few features of which were visible through the tracing paper

The needle bar, as described later, was developed and now, instead of pencil work upon the tracing, which is stretched over the completed dry assembly, the twin needle points are pressed through the tracing and each individual photograph in the assembly The pair of holes so made are easily relocated by a pencil line ruled along the bar at each operation The township and the outer limits of the mosaic, which are as generous as the photographs allow, are outlined with soft pencil upon the tracing after each photograph has been pierced with the needle bar points The best way to remove the tracing is to cut it off the board with the penknife, scoring the photographs for later trimming This produces a correctly shaped tracing which may be laid upon a sheet of artificial wood three sixteenths of an inch thick as a template to determine the size and the shape of the mount About three inches additional height is allowed for a title panel across the top

The process of transfer is usually interrupted at this point long enough to cut with a handsaw the correct piece of mount and to apply upon each side, by means of mucilage, a cover sheet of Kraft wrapping paper, an operation discussed under "wet assembly" The freshly covered mount is set aside to dry while the underlap of the photographs is trimmed off To hasten drying it may be stood with an edge presented to the blast of an electric fan

The underlap is that portion of a photograph hidden by an overlapping print Early experience showed that loose edges frequently resulted from the weak bond between the glossy emulsion on the underlap and the print cemented to it Contraction due to drying causes edge looseness where the underlap is excessive This looseness is prevented by discarding all but about one half of an inch of the underlap, thus providing each print with a maximum area of contact with the Kraft paper-covered mount underneath The looseness just mentioned must not be confused with edge curling due to unequal drying at the time of assembly

When one begins the dismantling of the dry assembly, about one-half inch of the tip of a china-marking crayon is inserted underneath the feathered edge of the last print in the final strip and a black line is traced around it upon the photographs below This operation is repeated with each print in the last strip before any are removed for trimming The marks so made insure that a safe margin of underlap will be left in all cases The photographs thus marked are removed and the excess areas are trimmed off along the black crayon lines just traced upon them Care is taken in tearing off waste portions to produce a good feather edge, since a square edge here will be noticeable through the overlap as an abrupt bump upon the surface and is very apt to cause a light reflection, seriously affecting the value of the copy mosaic Boundary prints are also trimmed at this time along the knife marks made when the tracing was cut from the board As the prints are trimmed they are laid face up in an orderly pile upon the back table

When the paper-covered mount is dry the tracing is fastened upon it with a few small pieces of "Scotch tape," a rubber base adhesive tape made of heavy crêpe paper and used by draftsmen in place of thumb tacks to secure drawings to the board

The needle bar or bars used before are again pressed through the tracing in the identical holes made by the first operation The mount is dense and care must be taken not to break off a needle point As each location is transferred it should be marked with a pencil check When it is certain that no photograph position has been neglected the tracing is removed and discarded

At the starting point the first photograph is relocated in its proper position by means of the needle bar, and its outline is traced upon the mount with a soft lead pencil The remaining prints in the order of their sequence are relocated with the needle bar, and those edges that do not overlap any preceding print are outlined upon the mount When all the photographs have been outlined the wet assembly may be started

The covering of paper on both sides of the wall board, described for use on mount in the Appendix, is necessary to control warping, which would occur if only one side of the board were covered The front surface is covered to make the pin holes from the transfer operation visible, as well as to cover up the oily surface of at least one brand of board used, thereby improving the glue bond

board and prints The back paper is always added afterward to balance the shrinkage stresses and to prevent warping of the mount

The transfer tracing was used as a template to obtain the correct size of the board to be used as a mount This board now serves as a pattern for three pieces of paper, which are cut to a size approximately three fourths of an inch less each way than the board itself This under-sized paper will equal the size of the mount when wet One sheet is rolled up and saved for backing the board after the assembly has been made The other two are wetted thoroughly on both sides and mucilage is spread evenly on the paper rather than upon the board itself The inclusions of air under the paper are removed by lifting the corners and smoothing with a cloth progressively from the center to the corners of the large sheet After the paper is smoothed on both sides of the board the edges are bound with gummed paper tape one and one-half inches wide and the board is set up on edge so that both surfaces may dry evenly

The wet method of applying prints to the mount entails the soaking or floating of them, together with a certain amount of trimming at assembly of undesired portions and constant manipulation of the whole mass while wet, to arrive at a desired assembly The excess glue is removed by wiping and cleaning with a damp sponge after the mosaic has dried It is obvious that during such a wet assembly the prints will be fully expanded with moisture, and this is one of the things our present semiwet system avoids

The number one print of the dry assembly is also the first print to be glued into its place upon the mount The front and back sides of the first print are sponged in rapid succession upon a linoleum or other suitable surface It is then laid face down upon a pad of paper towels, where thinned mucilage is applied with a brush evenly over the back surface It is next quickly placed face up in its proper position on the mount and smoothed from the center toward its edges in all directions with a damp sponge to force out all entrapped air bubbles and is then dried in like manner with a soft dry cloth Its correct location is shown by its penciled outline upon the mount, and any necessary adjustments must be made without delay because the mucilage acts as a lubricant only while wet and its moisture is quickly absorbed into the Kraft paper beneath All freshly laid edges are carefully pressed and dried with the cloth-covered finger tips before passing on to succeeding operations A photograph applied as de-

scribed above adheres strongly to the mount in about two or three minutes

The second print is wetted on both sides and placed upon a clean paper towel for application of the mucilage The paper towels are discarded after being used once to prevent the front surface of the print from becoming excessively sticky In smoothing out and drying this and successive prints in their places care must be taken not to rub against an edge with the sponge or wiping cloth Such a movement would surely displace the fine feather edge and probably split it so as to cause separation of the emulsion from the paper No harm results if the wiping action is with and not against the overlap It is important that the edges of newly laid prints, especially the overlapping edges, should be pressed out firmly to expel the excess mucilage, thus permitting the edges to adhere before the evaporation of moisture from the emulsion side causes edge curl The commercial arabic mucilage used is heavy and viscous and should be thinned with about equal parts of water to facilitate the edge-squeezing operation, thereby guarding against unwelcome edge curl A roll curtain was first used to retard edge evaporation This prevented the trouble, but its use interfered with the assembly work and the thinning of the mucilage, which proved adequate, was adopted in its stead In this way the entire assembly is completed, with a place for each print and with each print as near as may be in its place Expansion sometimes forces the prints off their outlines, but the penciled control is still useful in keeping the assembly uniform, if large, and the result is good

A strip of Kraft paper is glued across the top of the assembly and the title is located and mounted in the center of this panel The mosaic is then turned over and a second back paper, saved from the previous mount-covering operation, is applied to the back We now have two sheets of paper on the back balancing one sheet and a mosaic of photographs on the front This symmetrical treatment will insure that the finished board will remain flat

Gummed paper tape is again used to bind the edges of the mount, care being taken this time to display a uniform width of tape around the front borders of the mosaic The length of the one-mile diagrammatic scale on the mosaic title is one sixth of the measurement between the top township corners, if the township is found to be of regular size on the General Land Office plat Although the original

Land Office plat may depict a township as a square, the same township as built up in mosaic form is often far from square This is due to variation in scale of the photographs and is allowed because experience has taught us to show as nearly 100 per cent of the area as possible and then to try in the process of photographic copying to correct the shape of the mosaic

In the title there should appear along with the scale such items as north point, township, county, state, name of agency which took the photographs, and the year the pictures were taken (see Pl LXXXVII)

If water surfaces occurring in an area have mirrored the sun's rays into the *camera lens*, the water body will appear dead white, while normally the dark under-water vegetation and muddy bottoms will give such bodies of water an almost black color The artist's air brush (see Pl LXXXVII), filled with black water color, is used upon these light water areas until all lakes and large streams are of a uniform gray or black color Excess color around the margins of a lake may be wiped up with a little cotton on a small wooden applicator (see Pl LXXXVII) Shoals and submerged sand beaches are not covered with color if their presence is known After water surfaces have been retouched they may be sprayed with a transparent fixative or lacquer to prevent accidental scratching of the delicate water color film, this procedure, however, is not practiced at present

Water features are next labeled with white ink, which is used for names of lakes, large rivers, and bays All land features are in black ink Mountains, points, islands, and cultural features such as towns are included in this group, as well as section numbers and county boundary names

The assembly man signs each mosaic in the lower right-hand corner and writes upon a small piece of note paper any special instructions that will aid the photographer in making a good reduced copy of the mosaic This note is attached to the mosaic by means of "Scotch tape" The scale appearing in the title is always to measure two inches on the copy, and, unless there is a statement to the contrary, the township should appear square and regular upon the reduced copy

Our regular semimatte finished paper is the most popular and is usually cloth-backed and provided with a hinge on the left-hand edge (see Pl LXXXVII) Glossy and dead-matte papers are also

furnished The glossy paper gives maximum brilliance of detail and the dead matte permits pencil work upon the print This last finish is used by field parties in mapping soils and cover with colored pencils and ink directly upon the copy mosaics

When the original mosaic and prints are returned from the photographer the copies are filed in a loose-leaf binder and the originals placed vertically in a special file by counties to facilitate easy removal of individual mosaics for reference

APPENDIX

The following notes on the equipment used by the Geological Survey of Michigan are added for the benefit of persons interested in the making of airplane photograph mosaics

Assembly board — The assembly board rests at an angle upon a vertically adjustable wall rack or easel The wall rack is hung from a strong metal picture groove in the wall by two light-weight window-sash cords These are threaded around grooved shives on a pair of overhanging arms, thence they are wound upon a light-weight crank shaft near the bottom of the rack This shaft is locked by a sliding bolt (see Pl LXXXVIII, Fig 1)

The overhanging arms cause the top of the wall rack to press firmly against the wall at all times To accommodate different loads the length of these overhanging arms is made adjustable by means of a series of holes through any one of which a removable pin fixes the position of the outer shive A 4-inch shelf along the base of the assembly board provides a convenient place upon which to lay small tools between operations

The variable height of this wall rack is a boon to the assembly man who would, without some such device, spend many tiresome hours each day reaching over the edge of a flat-topped table Such a working posture is poor because air photographs may not be accurately matched and fitted unless the workman's line of sight is normal to the working surface This reason alone justifies the use of some form of wall rack, tilting drawing table, or easel

A pair of letter files standing side by side make an acceptable substitute easel, upon the slightly opened lower drawers of which the assembly board is rested

The assembly boards shown (see Pls LXXXVIII–LXXXIX)

measure about 42 by 45 inches They are amply large to accommodate our standard township assembly of 36 square miles on a scale of 1,000 feet to the inch They are ordinary soft insulating wall board of a brown color, from which the tiny wire staples used in the dry assembly may be easily withdrawn with the finger nail, an important detail

Since the accompanying photographs were taken a new type of nonsuspended wall rack has been designed It consists of an assembly-board carriage that runs upon a portable wall frame The wall frame is made of one-inch pine, four feet wide by seven and one-half feet high Its top corners press against the wall through two felt-covered adjustable bearing blocks, and any tendency to tip away from the wall is checked by means of two projecting feet securely bolted to the broad bottom ends of the vertical side members The assembly-board carriage is equipped with small flanged wheels, which run upon the exposed edges of the two vertical side members of the wall frame These members are narrow at the top and wide at the bottom, thus forming an inclined track which, through gravity, operates to keep the carriage seated securely at all times The hand crank, which is installed upon the wall frame, does not travel with the carriage, and because the flanged wheels are mounted at the extreme corners of the carriage the stability thus gained permits the use of the staple-driving machine upon the outer edge of the dry assembly board Because the carriage rests squarely upon the rigid wall frame it needs but one supporting rope attached on its center line, the rails keep it square at all times

There is a full-length tray 6 inches wide supported by metal arms in a position between the operator and the movable carriage and on the same level as the back table Thus the tray does not move with the assembly board In short, the new units are portable, the hand cranks and working trays do not travel with the assembly board, which is held square by its flanged wheels between the side rails, and it is much easier to operate

Table — We use a special back table resembling a flat-topped desk, it is 38 inches high and provided with a drawer and some open shelves on one side and a special pocket for safe storage of original General Land Office maps so essential in the assembly of wild-land photographs This table has a brown linoleum top and is ideal for wet jobs such as this

Stool — The stool is adjustable for height and the seat rotates like that of a swivel chair. By pivoting upon this stool it is often possible to perform related operations between back table and assembly board.

Stapler. The stapler is a device similar to the common paper stitchers found in many offices for fastening two or more papers together with a clinched wire staple. The small wire staple is not clinched, but is driven straight into and flush with the surface of the photographs on the assembly board. Staples may be removed from the recommended insulating board with the finger nail or from a pine drawing board by means of a pointed and bent lifter furnished with each machine (see Pl. LXXXVIII, Fig. 2).

Trimming board — Two 8-inch squares of thin wall board (described under "mount" in this Appendix), with the rough side of the board beveled off to leave a clean sharp edge all around, are glued with smooth sides outward to opposite ends of a 4-inch wooden spacer block (see Pls. LXXXVIII, Figs. 1, 2, LXXXIX, Fig. 1). The 4-inch height of the spacer block is specified to prevent assemblyman's knuckles from striking the table top when a print is torn along the edge of the trimming board.

Knife. A small penknife with a sharp point is necessary for scribing and beveling prints. A few pieces of 000-size sandpaper will keep it sharp. Crocus cloth polishes the edge quickly. It is essential that the knife be sharp at all times.

Straightedges — One long steel straightedge is required for alignment of straight roads and similar features, and a short one of wood, or a large triangle of celluloid, or both, are handy for short projections and comparisons.

Scales — A 5-foot narrow steel tape, in a round metal case smaller than a man's pocket watch, which reels itself up at the press of a center button, is recommended for accurate measurements (see Pl. LXXXVIII, Fig. 1). An engineer's triangular celluloid-edged scale, 12 inches long, is necessary for laying out the average mile in the title block under "scale."

Needle bar — The term "needle bar" is applied to a brass bar $\frac{3}{16}$ of an inch square and from $1\frac{1}{2}$ to 5 inches long, having a pair of needle points inserted into drilled holes at either end and fixed with solder. A kettle knob, brass ring, or straight piece of self material may be fastened to the center of the bar on the top side for use as a

handle The points should not protrude more than $\frac{3}{16}$ of an inch The longer bars produce most accurate results, but short bars are necessary for occasional small bits of photographs in an assembly (see Pl LXXXVIII, Fig 2)

Mount — The mount is a thin hard wall board $\frac{3}{16}$ of an inch thick, of golden brown color It comes in all standard lengths up to 12 feet and is 4 feet wide The finished surface is very hard and smooth, the reverse side bears the imprint of a fine wire screen It weighs about one pound per square foot A smaller size of the same kind of board, $\frac{1}{8}$ of an inch thick, is lighter but less rigid Since there is danger of the prints becoming loose through the flexing of the mount, this size is not recommended for mosaics larger than 2 feet square The thicker board is successfully used for mounts as much as 4 feet square

Larger mosaics must be laid upon thicker boards obtainable in 6-foot widths Loosely bonded boards designed primarily for insulating value are not suitable At least one surface should be fairly smooth

Mucilage — Good glue or mucilage is important A quick-setting library paste is unsuitable, for each photograph must be adjusted after it is applied It must be soluble in water, since sometimes the assembly must be reworked Any mucilage containing water causes photographs to expand The ideal bonding medium, therefore, would cause a minimum of expansion Rubber cement deteriorates in time and permits edges to curl A heavy commercial mucilage made of gum arabic seems to work as well as anything we have tried (see Pl LXXXIX, Fig 2) Various formulas call for from one to two or more pounds of gum arabic to one gallon of water The mucilage we are using successfully is heavier in body than that made in either of the proportions of gum and water just mentioned In addition, it has a pleasant odor and does not become rancid with age and hot weather A foul-smelling mucilage is a nuisance around any office

Glue pot — From the original container, which may be a one-gallon jug or a one-quart bottle, our mucilage is transferred in small quantities to a specially constructed square metal dish Heavy gauge copper is recommended for the material, since our first dishes made of galvanized steel have begun to rust within a year The dish, about 1½ inches deep by 4 inches square, is provided, near the front

edge, with a crossbar over which the brush is wiped or upon which it may be rested (see Pl LXXXIX, Fig 2)

Brush — A 2-inch varnish brush is used to spread the mucilage evenly and thinly Such a brush (see Pl LXXXIX, Fig 2), with the bristles vulcanized in rubber, costs about 25 cents

Paper towels — The dampened photographs are laid face down upon paper hand towels during the operation of applying the adhesive In actual wet assembly work about one third of the mucilage used is discarded with the spent towels Upon first thought this may seem an unnecessary waste However, if the face of the photograph is not kept free from adhesive in the first place, the same waste mucilage must be sponged off the mosaic surface later, a messy operation which can be avoided through the use of paper towels (see Pl LXXXIX, Fig 2)

Sponges — Good sponges are absolutely essential to good work upon air-photograph mosaics Only the best quality of small-sized wool sponges should be considered, and before being used they should be thoroughly washed out to remove bits of sea shell and grit The emulsion on a photograph is very tender when wet and a soft wet sponge cannot be excelled for sponging and cleaning

Basin — An 8-inch aluminum basin with flat bottom will hold sufficient water for sponging purposes

Wiping cloths — Mention should be made also of the soft cotton wiping cloths so useful for rough-drying the wet surfaces of photographs and as pen wipers After use they are stiff with mucilage and should be thoroughly laundered from time to time The adhesive recommended is easily rinsed out in hot water Discarded sugar bags are excellent

Lettering guides — Ownership of or access to a set of mechanical lettering guides and pens is very desirable for the finishing of a mosaic The ordinary draftsman's instruments also will be useful from time to time, especially the bow pen and the ruling pen

Air brush — Compressed carbon dioxide gas is used to operate the artist's air brush (shown in Pl LXXXVII) employed for touching up water areas

Crayon — A china-marking crayon in black makes legible marks upon glossy prints that may be wiped off completely with a dry soft cloth without injury to the photograph

Miscellaneous — Other items of equipment might include suitable

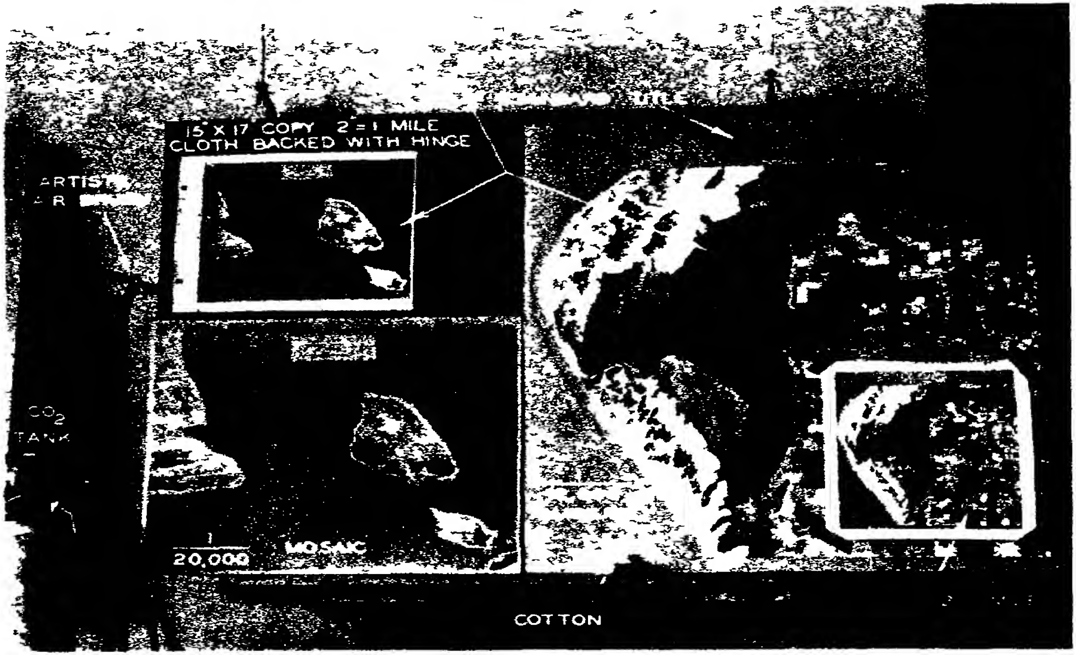
envelopes for sorting and filing photographs by strips, a quantity of manila Kraft wrapping paper for use as a mount cover, gummed paper tape 1½ inches wide, and quantities of clear celluloid for grids. From time to time the ingenuity of the assembly man will produce special items of equipment, such as celluloid templates for locating the section numbers.

The items of equipment discussed above are important. Good tools are important on any job, and the difference between good and poor results in any work often rests in the tools employed rather than in the ability of the workman. At all events, a workman using good equipment cannot blame his tools for poor results.

DEPARTMENT OF CONSERVATION
LANSING, MICHIGAN

PLATES LXXXVII-LXXXIX

PLATE LXXXVII



Representative sample of work

Fig Dry assembly in progress

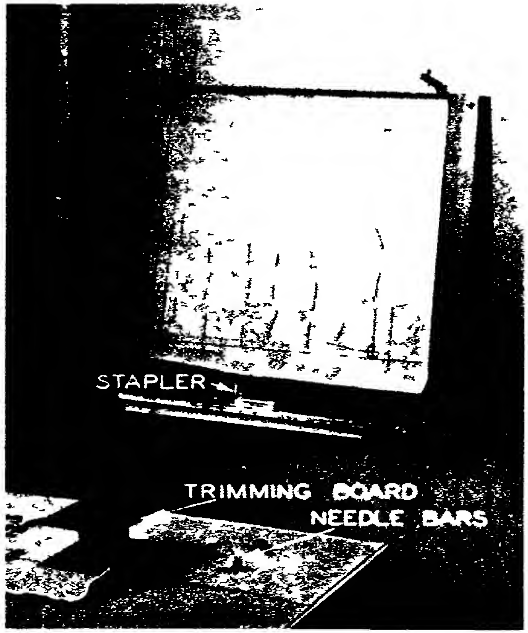
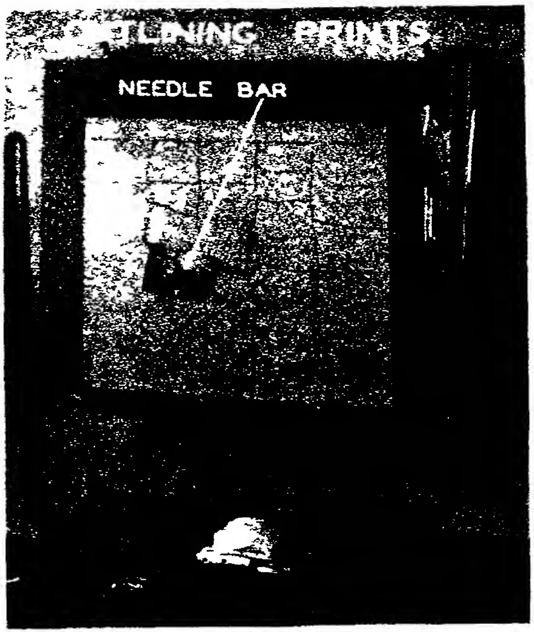


Fig 2 T [illegible] operation

PLATE LXXX



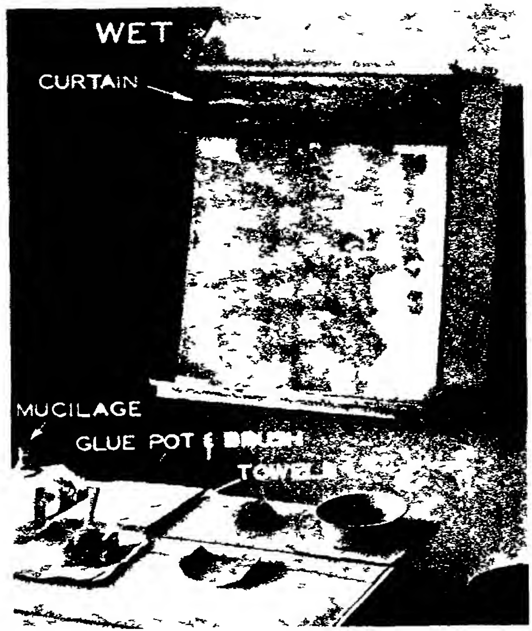


FIG. 2. Wet assembly in progress

ABANDONED CHANNELS OF THE LOWER HURON RIVER, MICHIGAN

JAMES WILLIAM BAY

INTRODUCTION

THE Huron River is one of the major drainage lines contributing to the flow of the Great Lakes system between the head of the St Clair River and the southwestern end of Lake Erie Its entire valley in Washtenaw, Wayne, and Monroe counties [1] has resulted from mouthward extension of the river over land previously occupied by the Huron-Erie lobe of Late Wisconsin glaciation and the subsequent glacial lakes of the Lake Huron and Lake Erie basins Between the lowest of these glacial-lake shore lines (that of Lake Elkton) and the present drowned shore of Lake Erie there is a network of distributary channels which the river has abandoned This is the Lower Lake Plain section of the river Its channels tell the story of the descent of lake waters in this area from the Elkton level to that of Lake Erie

The features of the Lower Lake Plain section of the Huron River valley are shown on Map 35, together with the distributary channels of the Detroit River which connected Lake Rouge and Lake Erie [2] In order to prevent confusion in their description the Huron River distributaries are numbered Channels 13, 16–18, and 20–23 are shown on the maps of the "Detroit Folio," [3] but are there undifferentiated from the present valley floor The others have not previously been mapped

TOPOGRAPHY OF THE CHANNELS

The Huron River distributaries cover an area about ten miles in length and four miles in maximum width For the most part they

[1] The distance from Base Line Lake at the Livingston-Washtenaw county line to Lake Erie is fifty-six valley miles

[2] For the description and interpretation of the Detroit River distributaries see F Leverett and F B Taylor *The Pleistocene of Indiana and Michigan and the History of the Great Lakes*, *U S Geol Surv*, *Mon 53* 487–496 1915

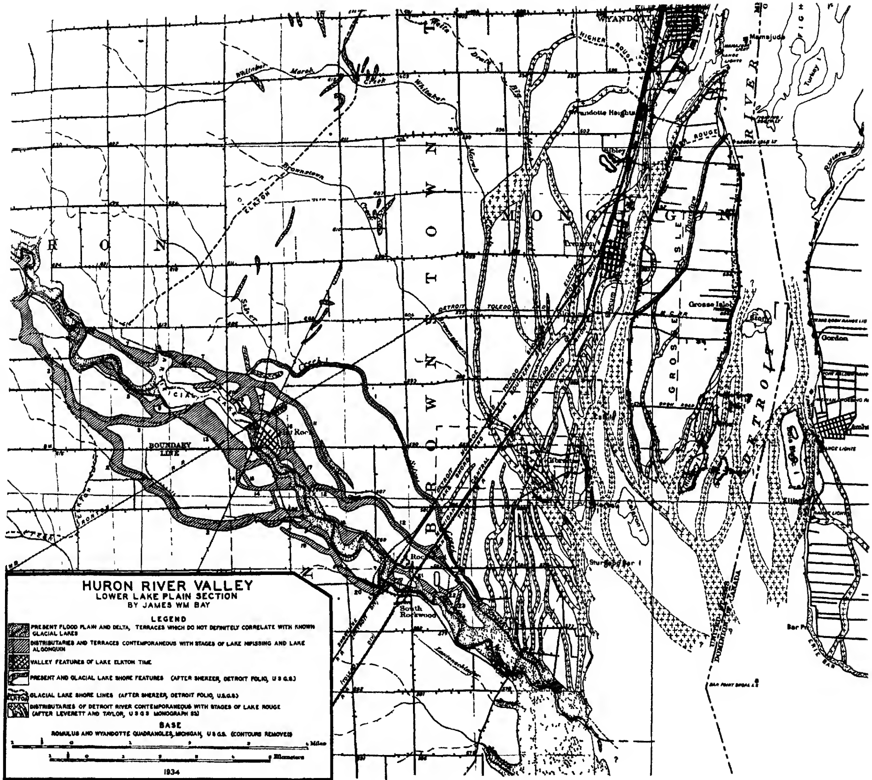
[3] Sherzer W H, "Detroit Folio," *Geol Atlas of the United States*, No 205 1916 Maps of Areal Geology of Romulus and Wyandotte Quadrangles

are flat-bottomed channels measuring from forty or fifty feet to a quarter of a mile across and from five to ten feet in depth. The majority of them are dry. Some are occupied by streams, mostly of the intermittent type, too small to have cut the broad depressions in which they now flow. The Silver Creek channel is a single exception, but the headwater portion is dry and shows channel characteristics so distinctly that it must be regarded as having the same origin as the others. Elevations on the flat floors of these features range between 575 and 612 feet above sea level, with those channels farthest from the center of the system at the highest levels. Many of the lower channels have cut across the heads of the higher ones, so that there is a definite ascent from one to the other. The present river occupies a course which nearly bisects the whole system longitudinally.

Channel 1 is occupied for most of its length by Silver Creek. At its headward end it appears to have drawn water from Channel 7 and east of the present site of Rockwood, from several of the Detroit River distributaries. Near the headwater portion it has cut deeply into a high sand ridge. The extreme head stands higher than Channel 7.

On the south side of the river Channels 2–6 constitute a group which carried a large portion of the water and which appears to have been abandoned relatively early. Channels 7–11 on the north side of the river seem to have had a similar history. Channel 2 is about 612 feet in elevation one and one-half miles south of its head and 586 feet at its mouth. It is the largest of the channels. Channel 3 served as a connection between number 2 and those to the north. The elevations in Channels 5 and 6 range from 604 to 606 feet above sea level, in Channels 7–9, from 601 to 603 feet. These were two parallel lines of flow with a possible connection by way of Channels 6 and 8. The present river flows along the southern of these two lines and has cut into it, leaving the upper end of Channel 5 as a terrace on the south side of the valley. Channels 11 and 12 carried water from 7 and 17. Near their junction with Channel 1 they were connected with the Detroit River distributaries west of Rockwood.

In the vicinity of Flat Rock a group of distributaries which were cut lower than those just described indicates that in the later part of the development the river waters had been concentrated in a group of channels toward the center of the system. This is also



HURON RIVER VALLEY
LOWER LAKE PLAIN SECTION
BY JAMES WM BAY
LEGEND
PRESENT FLOOD PLAIN AND DELTA, TERRACES WHICH DO NOT DEFINITELY CORRELATE WITH KNOWN GLACIAL LAKES
DISTRIBUTARIES AND TERRACES CONTEMPORANEOUS WITH STAGES OF LAKE NIPISSING AND LAKE ALGONQUIN
VALLEY FEATURES OF LAKE ELKTON TIME
PRESENT AND GLACIAL LAKE SHORE FEATURES (AFTER SHERZER, DETROIT FOLIO, U S G.S.)
GLACIAL LAKE SHORE LINES (AFTER SHERZER, DETROIT FOLIO, U.S.G.S.)
DISTRIBUTARIES OF DETROIT RIVER CONTEMPORANEOUS WITH STAGES OF LAKE ROUGE (AFTER LEVERETT AND TAYLOR, U S G S MONOGRAPH 53)
BASE
ROMULUS AND WYANDOTTE QUADRANGLES, MICHIGAN, U S G.S. (CONTOURS REMOVED)
Miles
Kilometers
1934
DETROIT RIVER
GROSSE ISLE
MONGUAGON
BROWNSTOWN
Mamajuda
Wyandotte Heights
Sibley
Trenton
Grosse Isle
Gordon
South Rockwood
Sturgeon Bar I
ERIE BAR
ELKTON
BOUNDARY LINE
Brownstown
HIGHER ROUGE

MAP 35

true near Rockwood and South Rockwood The Flat Rock group consists of Channels 13 17, and possibly 12, which range from about 585 to 593 feet above sea level The second group is composed of Channels 18, 20, and 21, at about 579 to 580 feet elevation

Channel 19, which appears to have been formed by overflow from Channel 2, did not function long enough to cut back by headward erosion to the latter Therefore, it must have been abandoned relatively early

SUMMARY AND INTERPRETATION

The pattern and close articulation of the Huron River distributary channels indicate that the descent of water from the Lake Elkton level to the Algonquin stages of Lake Erie was extremely rapid, possibly more rapid than the transition between any of the other glacial lakes of the Lake Erie basin Instead of the gradual mouthward extension of a single channel, which took place over most of the area upstream, the river waters seem to have divided into a braided system upon a newly uncovered surface of only slight relief At first the flow of waters was through the entire network, but as the cutting continued the waters concentrated in the channels nearest the center of the system, so that these were cut lower than the outer ones

Channel 1 had its beginning as soon as the lake waters had lowered so that cutting could begin on the sand ridge at its headward end This channel appears to have been the first to be discontinued because Channel 7, which was abandoned relatively early in the series, is cut beneath it at their junction There is additional evidence of this conclusion in the lower part of Channel 1 at its intersection with the Detroit River distributaries east of Rockwood These channels, which were believed to have been formed by overflow from the main channel to the north and which were among the first of the Detroit River series to be discontinued,[4] have the same level as Channel 1 at the junctions

Channels 2–11 seem to have been the next to be abandoned They stand at higher elevations than the channels nearer the center of the system, and distinct breaks of slope occur between 7 and 16 and between 4 and 14 The relation of Channel 12 to the others is uncertain Its head is level with Channel 17, but the connection with 11 is obscured by recent erosion and a roadway

[4] Leverett and Taylor, *op cit*, p 491

The group composed of Channels 13–18, 20, and 21 were the last to become dry The cause of this was possibly one of the two low stages of Lake Erie during Lake Nipissing and Lake Algonquin times

The present valley bottom is from four to five feet below the lowest channel floors between Flat Rock and Rockwood The valley is drowned upstream as far as South Rockwood, and a small delta covering an area of about two square miles [5] has been deposited in it

The evidence at hand indicates that the Huron River distributary channels were abandoned by down-cutting to a low base level Whether this was the low stage of Lake Erie during Lake Algonquin or Lake Nipissing time or both is at present indeterminable

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[5] Sherzer, W H, "Geological Report on Wayne County," *Mich Geol and Biol Surv*, Publ 12, Geol Ser 9, p 117 1913

VALLEY-TRAIN DEPOSITS IN THE NORTHERN PENINSULA OF MICHIGAN

STANARD G. BERGQUIST

IN A recent paper dealing with the glacial geology of Iron County, Michigan, the writer made special reference to the widespread distribution of glacio-fluvial sediments in the major valley ways (Pl XC, Figs 1-2) of the area (see Map 36) Attention was called likewise to the general occurrence of very fine silt which is spread out as a thin mantle over the surface of the gravel trains and is interspersed through the adjacent interfluvial till plains [1]

More detailed studies, made recently, of the Pleistocene section exposed in numerous mine caves within the till-plain area in the vicinity of Iron River have revealed a succession of geologic events which are not readily recognized on the surface Four distinct episodes of Pleistocene activity are recorded in the formations which overlie the pre-Cambrian floor These events are associated with various stages of glaciation, extending from pre-Wisconsin into late Wisconsin

PRE-WISCONSIN DRIFT

Basal till sheet

Resting directly upon the pavement of the pre-Cambrian complex in the vicinity of Iron River is a sheet of till which ranges from twenty to forty or more feet in thickness (Pl XCI, Fig 1) It seems to be confined largely to the preglacial upland areas and is noticeably absent in the rock-sculptured valley floors The drift here is composed largely of bouldery till, definitely unassorted but somewhat compacted Polished and faceted pebbles, cobbles, and large erratics, consisting in the main of quartzite, granite, and other acidic rocks, together with dark slate and an abundance of more basic types such as diabase and basalt, are embedded in the ground mass of distinctly weathered clay, silt, and sand

[1] Bergquist, S G, "Glacial Geology of Iron County, Michigan,' *Pap Mich Acad Sci, Arts and Letters*, 16(1931) 368 1932

South of the village of Iron River, in the Berkshire cave, near Gaastra, the drift is of a rust brown and contains a considerable quantity of comminuted limonite, apparently of local origin A pebble count of a characteristic sample of the basal till in this cave exposure reveals the presence of the following material

Material	*Percentage*
Quartzite and quartz	26
Granite and aplite	8
Limonite (weathered)	12
Slate (dark-colored)	10
Basalt and diabase	44

The larger fragments are dominantly basalt and diabase, with quartzite and quartz together forming a considerable portion of the total content Some of the larger pebbles and fragments of the basalt and diabase show but a very small degree of weathering The smaller fragments, on the other hand, seem to have undergone appreciable decomposition and they possess an outer thin zone of weathered limonite The finer matrix in this till is made up essentially of more or less rounded, frosted, and translucent particles of quartz These are generally coated with a fine dusting of limonitic powder, which also accounts for the color of the formation as a whole No calcareous fragments were observed in the sample and no reactions for carbonate were obtained, conditions which may be attributed to the greater age and the more profound weathering of the drift in this section

Three miles to the north, in the Davidson (No 1) mine cave, in the SW ¼, SE ¼, Sec 14, T 43 N, R 35 W, the exposed basal till is a decidedly lighter or a cinnamon brown, and contains much less of the intermixed iron ore In this section the older till resembles more the younger surface drift, in composition as well as in color In a characteristic sample of the drift from this locality there was found the following material

	Percentage
Quartzite and quartz	36
Granite and aplite	14
Schist (much weathered)	3
Limestone and dolomite (fresh)	6
Slate (dark-colored)	15
Basalt diabase and diorite	26


MICHIGAN
DEPARTMENT OF CONSERVATION
LAND ECONOMIC AND GEOLOGICAL SURVEYS
COOPERATING
GEOLOGICAL MAP
SHOWING
SURFACE FORMATIONS
OF
IRON COUNTY
WISCONSIN

MAP 36

Although the stratigraphic relations of the basal till in the Berkshire and Davidson mine caves are identical so far as bedrock and overlying gravel deposits are concerned, still there is a substantial difference in composition and likewise in the degree of weathering In the basal till of the Davidson cave the larger pebbles and cobbles are somewhat smoothly polished and some are definitely faceted They are composed essentially of quartzitic and basaltic fragments with a predominance of the former The smaller pebbles, those below the size of a small pea, are angular to rounded and seem to lack the smoothly polished surfaces which characterize the larger fragments The finer-textured portion of the drift is made up largely of angular to rounded frosted grains of quartz, with a subordinate assemblage of intermixed fragments of fairly fresh basalt, diabase, and dark-colored slate The sample contains also some unweathered limestone and dolomite pebbles, together with scattered minute weathered fragments of the same material, and yields a liberal amount of effervescence with dilute HCl It is apparent from the calcareous character of the basal drift in the Davidson mine cave that weathering has not progressed to the same advanced degree as in the Berkshire cave This may be due to one of several circumstances, or to a combination of them, among which may be cited (1) the relative age of the deposit in the two localities (2) the possibility of more rapid burial of the gravel plain in the Davidson cave area owing to a sudden abrupt readvance of the ice before much weathering had been effected, and (3) the variations in the source of material included

On the premise that there is a decided difference in the age of the material of the deposit in the two areas, it may be inferred that the rate of retreat of the ice sheet which contributed the till was extremely slow

EARLY WISCONSIN DRIFT

Glacio-fluvial sediments

Immediately above the basal till sheet in the upland interfluves and lying more or less directly in contact with the rock floors of the intervening valley ways there is a formation composed essentially of stratified glacio-fluvial sediment This deposit, ranging in thickness from fifteen to forty or more feet, is made up of alternating beds of gravel and sand of varying degrees of texture (Pl XCI, Fig 2) Subangular to rounded grains of quartz comprise the bulk of the

constituents in the finer material, although subordinate amounts of basalt and slate are also intermixed The pebbles and cobbles of the coarser fractions are fairly well rounded, and many exhibit distinct triangular faceting

This intermediate formation of stratified drift is well exposed in both the Berkshire and the Davidson caves, where it rests upon the basal till A pebble count was made of characteristic samples of the deposit from each of these localities, and the comparative results are given in the accompanying table It will be seen from the tabulation that quartzitic, granitic, and basaltic constituents predominate in each of the samples It is noteworthy that the dark-colored or basic rock fragments appear not to have undergone a great amount of weathering, for they are as fresh as the light-colored constituents

Material	*Berkshire Cave* Percentage from 100 pebbles	*Davidson Cave* Percentage from 200 pebbles
Quartzite and quartz	27	35
Granite and aplite	21	17
Gneiss	1	0
Schist (fresh)	1	1
Schist (weathered)	7	0
Limestone and dolomite (fresh)	9	6
Sandstone	2	2
Basalt, diabase, and diorite	23	30
Slate (dark-colored)	9	8
Lignite	0	0 5
Banded jasper	0	0 5

It is questionable whether this intermediate bed of stratified material is associated with the ice invasion which is related to the older basal till or to that which developed the overlying surface sheet The mineral and rock fragments, however, more nearly correspond in composition and degree of weathering to the younger rather than to the older drift In all events it lies between the two till sheets and is intermediate in age

That the stratified deposit is of widespread and extensive occurrence is recognized by its presence in various caves, shafts, and drill holes scattered through the area It appears to form a more or less continuous feature below the surface cover throughout the greater portion of the till plain

MIDDLE WISCONSIN DRIFT

Surface till sheet

In the upland areas which form the divides between the adjacent valley ways there is superimposed upon the stratified formation a younger till sheet which in the exposed portions ranges from twenty to thirty-five feet in thickness It is undoubtedly much thicker in certain areas This till sheet was laid down by a tongue of ice located directly west of the Green Bay lobe, referred to by Weidman[1] as "the Langlade lobe" It deployed across the area in a generally northeast-southwest direction The numerous drumlins which are distributed over the surface of the till plain in the vicinity of Iron River are more or less parallel in their alignment and strike in a direction which varies from S 5° W to S 40° W This is in accord with the trend of the glacial striae which are found on the rock pavement in various localities The drift in this plain is composed of bouldery clay intermixed with a considerable amount of gravel and cobble, which may have been derived either by incorporation of material from the gravel plain which the glacier overrode or through glacio-fluvial activity within the advancing ice sheet

The constituents of the surface till plain are largely fragments of quartzitic, granitic, and basaltic derivation Quartz predominates, however, in both the coarser and the finer fractions of the drift, although the more basic materials are likewise important The fragments of rocks and minerals, whether of basic or of acidic nature, do not show evidence of excessive weathering and appear relatively fresh in the mixture Intercalated with the coarser till and at times attaining a thickness of several feet in the surface depressions and pockets is a finely comminuted siltlike material which in composition and physical character bears a very close resemblance to the fine fluvial flour which mantles the surface of the adjoining valley-train deposits It seems quite probable that this finer sediment was carried on to the till-plain area from the valleys by wind activity and is thus of aeolian development

LATE WISCONSIN DRIFT

The late Wisconsin drift of the area is associated intimately with the activities of the Superior lobe, which moved into the Lake

[1] Weidman, Samuel, "The Geology of North Central Wisconsin," *Wis Geol and Nat Hist Surv*, Bull 16, Ser 4, p 492 1907

Superior basin from the northeast and advanced southward across a small portion of the Northern Peninsula The terminal moraine which is associated with the activities of this ice tongue lies directly to the north of the till plain of the Middle Wisconsin invasion, it has been described in some detail in a previous paper [3]

Extending southward from the terminal moraine of the Superior lobe the glacial valleys are fairly well filled with glacio-fluvial sediments These were deposited as valley trains by melt waters issuing from the dissipating ice border during the waning stages of glacial activity The valley-train deposits (Pl XCII, Fig 1) are composed of alternating layers of coarse and fine sediment and contain a predominance of smoothly polished and faceted fragments of quartz, quartzite, and granite, with scattered basic materials such as diabase, basalt, and diorite and occasional dark-colored slate The various gradations of texture developed in the stratified sediments of the valley ways is indubitable evidence that the velocity and volume of the water fluctuated from time to time during the process of sedimentation

A section through the valley-train deposits shows stratified material to be more or less persistent down to the floors of the valley in which deposition took place The basal portion of the well-sorted material is intercalated with boulders and large erratics, which are undoubtedly the concentrated remnants of the oldest till Occasional scattered erratics are found also in the higher levels of the deposit and may represent the concentrated residuals of the younger till sheet The apparent absence of finer till in the lower part of the valley-train deposits seems to harmonize with the view that in the early stages of deglaciation by the Langlade lobe protracted melting continued to supply an abundance of melt water as the glacier retreated slowly northward to lay down its load of till plain The ensuing streams occupying the partly filled depressions proceeded to scour out the finer portions of the basal till and left the coarser and heavier residuals as concentrates on the rock floors

The closing chapter of Pleistocene activity in Iron County is related to the deposition of a layer of silt which forms a comparatively thin mantle over the surface of the gravel in the valley trains (Pl XCII, Fig 2) This deposit of fine material was undoubtedly carried into the valley ways as glacial flour by slowly moving melt

[3] Bergquist, *op cit*, pp 365–367

waters which issued forth from the margin of the last remnants of the waning ice in the Superior lobe It represents the product of final deglaciation within the area and is unquestionably associated with fluvial activity The silt is not uniform in depth throughout the valley trains, but ranges from merely a few inches to six or more feet It rests directly upon the gravel and marks definitely an abrupt change in the transporting ability of the streams which occupied the valleys

The fine surface fluvial flour of the valley trains is composed essentially of subangular to rounded particles of quartz interspersed with a small amount of minute fragments of granite, gneiss, and dark-colored, more or less basic, rock The predominance of quartz seems to substantiate the opinion that acidic rocks rather than those of basic character contributed largely to the material The basic rock constituents which are scattered through the mixture are not unlike the quartz in texture and structure Although fragmented by mechanical wear, they still retain their original properties and show no more evidence of weathering than do the associated quartz particles

The view has been advanced by several pedologists that the surface mantle of silt in this area is merely the weathered product of underlying parent gravel and that weathering has progressed rapidly to form the finer mantle because of the predominance of included basic rock fragments Microscopic examination of the material reveals, however, that although quartz is the predominant mineral there is also a relatively large amount of unweathered basic constituents If the ordinary processes of weathering have been able to change coarse gravel composed in large measure of quartzitic and granitic pebbles into a fine rock flour in a region so recently deglaciated, it seems logical to expect similar relationships, but on a much broader scale, to exist in the Southern Peninsula, where the surface has been exposed to weathering agents for much longer periods The theory so commonly held by pedologists, that surface soils should be related to the underlying parent material through the simple process of weathering, does not seem to hold true in this area Other geological factors besides weathering must necessarily be brought into the picture to account for the succession from very coarse to very fine textures as developed in the materials of these valley trains

Podsolization has played an important rôle in the development of a distinct profile in the surface silts. But, unlike the vertical changes

ordinarily found in a podsolized soil, there appear here to be two definitely bleached horizons Invariably, in the upland silts as well as in those of the valleys, the surface-bleached podsol is underlain by a dark brown illuvial layer with a heavy concentrate of iron oxide Then follows a second bleached zone, not quite so light in color as the surface podsol but, nevertheless, much lighter than the overlying brown layer This bleached horizon is underlain by a second brown subsoil, which in turn may be followed by *either a darker or a lighter zone* before reaching the gravel floor The lower bleached horizon is of geologic significance in that it probably marks the position of a former surface in which weathering had progressed sufficiently to initiate a podsol condition But before the process was very far advanced there was a renewal of sedimentation, which may have resulted in a complete mantling of the older soil, with consequent termination of the bleaching activity

In the upland interfluves of the till-plain topography the fine silt may be traced for some distance back from the valley ways Here it is thinly spread out in patches over the surface or intermixed with the material of the till plain In areas where the accumulations are of appreciable thickness they resemble very much the deposits in the valley ways in both mineral composition and profile

On the basis of their horizonal and textural similarities it seems plausible to assume that the upland silts are genetically closely related to the valley silts The writer is of the opinion that the fine flour which occupies the surface of the till-plain area was translocated by wind from the adjacent valley-train deposits during intervals when only a small amount of water flowed through the valleys Then the finer material of the valley flats situated above the channels had an opportunity to become thoroughly desiccated and was lifted into the atmospheric circulation and transported, sometimes for considerable distances, before finally settling There is a strong suggestion that the lower bleached horizon in the upland rock flour deposits may represent a former surface exposed to weathering during the interval when fluvial activity was finally restored in the valley ways The last melt waters which flowed into the valleys were capable of transporting merely the finer silts, although occasionally the velocity was increased sufficiently to move fine pebbles, which became intermixed in the mantle While the depressions were occupied with slow moving waters, translocation by the wind was minimized Hence at the

time of renewed fluvial deposition in the valleys the upland deposits were subjected to weathering, with the result that a weak podsol layer was developed When finally the ice sheet retreated northward to the point where melt waters could no longer find access to the train-filled valleys, desiccation again became an effective process and the finer silts were subjected to renewed atmospheric shifting They were then in part carried out of the depressions and on to the adjacent uplands, where they were spread out over the podsoled surface Eventually the encroachment of vegetation caused the soils to become more or less fixed, and then followed the natural sequence of weathering activities and the development of an upper podsol horizon in both the lowland and upland deposits

Thus, in conclusion, it may be inferred that fine sediments in the valley-train deposits are definitely of fluviatile origin On the other hand, the mantle silts of the uplands, although originally water-laid, were subsequently transferred by the wind and deposited eventually as loessial material

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PLATES XC–XCII

PLATE XC.

Fig. 1.—Valley of Iron River in the vicinity of the village of Iron River.

Fig. 2.—View from Stambaugh Hill looking south across the Valley of Iron River.

PLATE XCI

Fig. 1. Basal pre-Wisconsin till with overlying glacio-fluv near the bottom of Berkshire Cave.

Fig. 2. Alternating beds of gravel and sand in glacio-fluvial deposits immediately above basal till, Berkshire Cave, near Iron River.

PLATE XCII

FIG. 1.—Gravel bed showing faceted and polished pebbles in valley train of Paint River Valley, near Crystal Falls.

FIG. 2.—Surface fluvial silt resting directly on stratified gravel of valley train deposit, Champion gravel pit, near Beechwood.

DISCOVERY OF *ELEPHAS PRIMIGENIUS AMERICANUS* IN THE BED OF GLACIAL LAKE MOGODORE, IN CASS COUNTY, MICHIGAN

ERMINE C. CASE, IRVING D. SCOTT, BYRNE M. BADENOCH, AND THEODORE E. WHITE

IN 1929 the Museum of Paleontology of the University of Michigan received word of the discovery of large bones in a marl pit near the small village of Union in Cass County, Michigan. Investigation revealed that these were the bones of an elephant. Since such remains are relatively scarce in Michigan, the material was carefully preserved and is now mounted in the Hall of Evolution in the University Museums Building.

The skeleton was found during the excavation of a marl bed in the northwest corner of Porter Township, Cass County, Section 32, Township 7 S., Range 13 W. Mr. George Wagner, the owner of the pit, most generously donated the specimen to the University and aided materially in its recovery.

The position of the specimen gave an opportunity for a more accurate dating than any previously discovered, and so the help of Professor I. D. Scott and certain of his advanced students was enlisted to determine what could be made out from the associated glacial and physiographic features concerning the time of burial. The following is a report of the combined findings of all engaged in the study.

The specimen consisted of the major portion of the skeleton of an adult individual. The skull and tusks were not found, but all four of the cheek teeth were recovered in good condition. These teeth were determined by Dr. H. F. Osborn, of the American Museum of Natural History in New York, as those of *Elephas primigenius americanus*, the woolly or hairy mammoth of the American continent.

The humerus measures 3 feet 11 inches in length, which indicates a height of 10 feet 6 inches at shoulders, and a length of over 13 feet

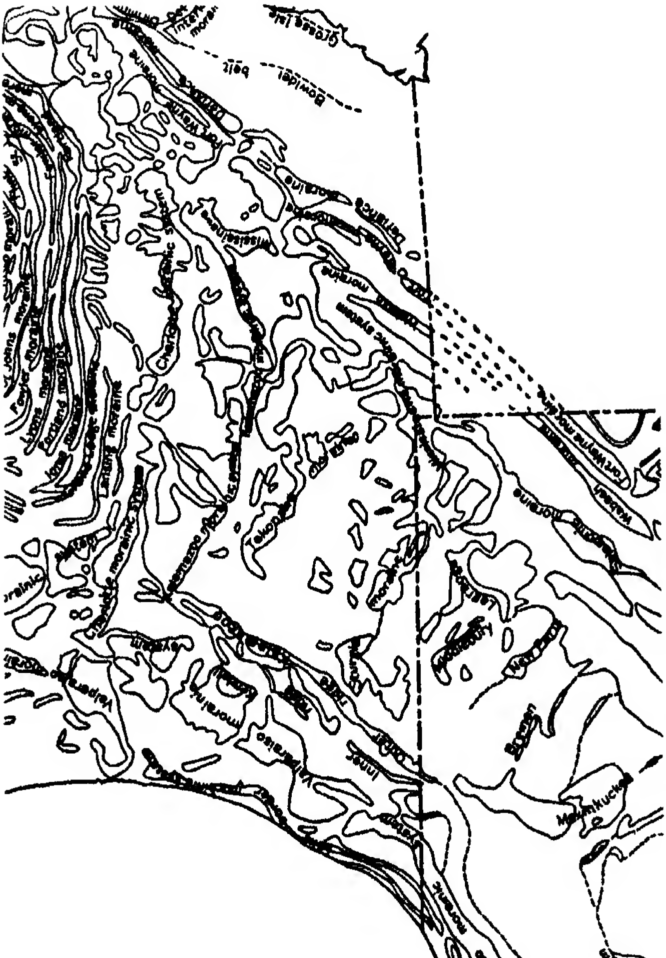
from the base of the tail to the base of the tusks, somewhat larger than the Indian elephant commonly seen in the circus or zoölogical garden Because of the absence of tusks, which reach a large size in the male, it is believed the skeleton is that of a female

The skeleton lay upon a yellowish, clayey sand which formed the bottom of the lake in which the marl developed Above the specimen lay 8 feet 8 inches of undisturbed marl, mostly white, but with bands of a brown and bluish color The marl is an almost pure calcium carbonate, formed from the shells of fresh-water invertebrates and by direct precipitation from the water According to a personal communication from Mr Calvin Goodrich, curator of molluscs in the Museum of Zoology, the abundant shells of lamellibranchs and gastropods preserved in the marl are indistinguishable from those of living forms The undisturbed condition of the marl beds shows that the cadaver was deposited before the marl was formed and did not sink down through all or any part of it at any subsequent time The condition of the bones, some badly injured by decay and the skull almost entirely destroyed, indicates that they lay partly exposed to the air for some time before burial These are important points, since they date the deposition of the specimen at the beginning of the formation of the lake

The examination of the physiographic evidence by Professor Scott and two of his advanced students, Mr B M Badenoch and Mr T E White, leads to the following considerations

The glacial deposits of the region south of the Saginaw-Grand lowland were formed by the Wisconsin ice sheet The Kalamazoo-Mississinawa morainic system may be taken as characteristic It consists of three parts, a western part with a northeast-southwest trend formed by the Michigan lobe, a central part with a northwest-southeast trend formed by the Saginaw lobe, and an eastern part with a northeast-southwest trend formed by the Huron-Erie lobe It will be seen from the map (Map 37) that these three sections form a large rectangular reëntrant

The Kalamazoo-Mississinawa morainic system marks the first great halt of the receding ice front Three earlier minor halts are indicated by the Lagrange, Sturgis, and Tekonsha moraines which, although not continuous, have a northwest-southeast trend and therefore were deposited by the Saginaw lobe It is important to note that there was a readvance of the ice to form the Tekonsha moraine



MAP 37 Southern Michigan and northern Indiana showing the moraines

and that the Lake Michigan sector covered the western ends of the Lagrange and Sturgis moraines[1] This advance was sufficient to cover the basin in which the skeleton of the elephant was found and for which the name "Lake Mogodore" is proposed This name was apparently used first by Mr John Eby, a former resident of the region, who probably derived it from the earlier name of Chapel Hill schoolhouse near the find of elephant bones, and from the local name, Mogodore Valley, applied to the lower end of the depression formerly occupied by an extension of the lake

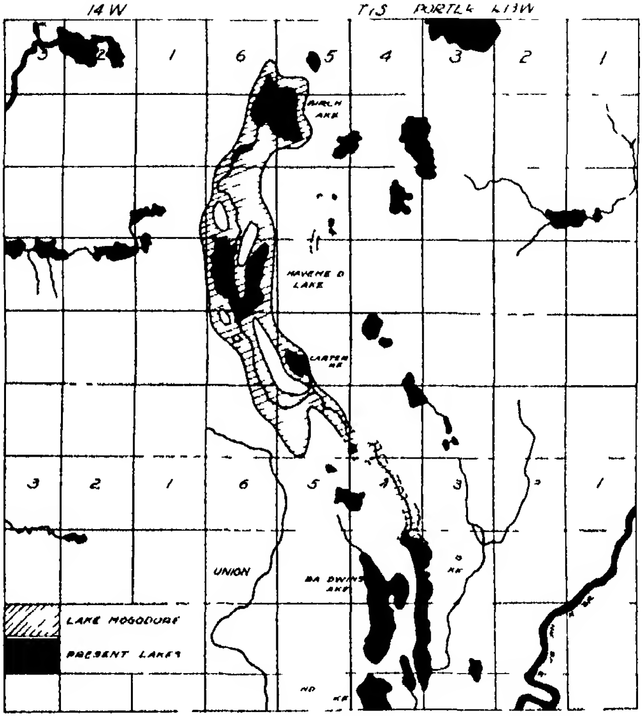
The borders of Lake Mogodore are identified by a well-defined offshore terrace, often consisting of marl, and in places by low, wave-cut cliffs The terrace stands between thirty-five and forty feet above the present level of Shavehead Lake and at about the same height above Carter Lake At Birch Lake, however, the terrace is only about six feet above the present lake level At its greatest extent Lake Mogodore had a total length of about six and one-half miles and a maximum width of about one mile It was irregular in shape and contained several islands, some of which were topped by wave action It covered nearly all of Sections 7, 18, 19, 30, 32, the southwest part of Section 5, the southeast part of Section 6, the northeast part of Section 31, the southwest part of Section 29, and the west half of Section 8, all in Township 7 S, Range 13 W (See Map 38)

The present drainage starts with Birch Lake, which is the highest in the Mogodore Basin It discharges southward into the western arm of Shavehead Lake The outlet of the latter lake takes a southeasterly course and is joined by the drainage of Carter Lake at the head of the Mogodore Valley The stream continues to the south and east into Long Lake and thence into the St Joseph's River The drainage of Lake Mogodore followed approximately the same course

From the explanation given above it is evident that Lake Mogodore came into existence after the recession of the ice from the Tekonsha moraine The condition of the bones necessitates postulating a rise in the level of the lake to its maximum stage but, unfortunately, no physiographic evidence of this was found

The date of burial of the elephant is uncertain It surely postdated Tekonsha time and must have been previous to the draining of the lake, the date of which is not known Assuming burial to have

[1] Frank Leverett, personal communication



MAP 38 A portion of Cass County Michigan, showing the site of glacial lake Mogodore and the find of *Elephas primigenius an*

taken place during the time between the formation of the Tekonsha and Kalamazoo moraines, the following glacial history ensued The Kalamazoo-Mississinawa system was followed by the Salamonie, the Wabash, and the Fort Wayne moraines, all of major importance The recession of the ice from the Fort Wayne moraine initiated a series of glacial lakes with Maumee, Arkona, Whittlesey, Warren, Algonquin, and Nipissing as the main stages

It is impossible to state with any certainty the duration of this time in terms of years, and any attempt must be in the nature of an

estimate Our best clock is Niagara Gorge, which was started in Algonquin time According to Dr Frank Leverett in a personal communication, it has taken Niagara River approximately 18,000 years to carve the gorge The same authority places the Tekonsha moraine at somewhat less than 35,000 to 40,000 years ago Thus the elephant must have lived in southwestern Michigan at some time less than 35,000 years ago, but how much later the genus survived in the state is still a question

University of Michigan

THE LOWER CHEEK TEETH OF THE FOSSIL HARE *PALAEOLAGUS HAYDENI*

LEE R DICE AND DORA S DICE

THE lower cheek teeth of the fossil hare, *Palaeolagus haydeni* Leidy, exhibit numerous changes during the life of the individual, and the teeth of young animals differ greatly from the teeth of old animals The changes in teeth during growth are so considerable that specimens of this one species have been assigned to four genera and to three different subfamilies of the Leporidae

Leidy [1] in his original description of *Palaeolagus* noted that some changes in the teeth are correlated with age Troxell [2] also has described briefly some of the stages of wear on these lower teeth By bringing together a large number of specimens from several museums we have been able to make a more detailed study of these age changes Since Troxell has described in some detail the age changes in the upper teeth, we have confined our attention to the lower series

Among the material which we have examined for this study are one hundred and ten fragments of lower jaws kindly loaned from the collections of the United States National Museum These specimens were collected in the years 1886–88 by J B Hatcher, and are from the White River Formation, probably in the Hat Creek Basin, Sioux County, Nebraska George F Sternberg has courteously allowed the examination of the types of *Protolagus affinus* and *Archaeolagus striatus*, which were collected in Central Wyoming The Peabody Museum of Yale University has generously loaned over four hundred parts of lower jaws, most of which are from the Oligocene (probably Brule clay) of Nebraska, but a few are from localities in Colorado and Wyoming

[1] Leidy, Joseph, "On the Extinct Mammalia of Dakota and Nebraska, Including an Account of Some Allied Forms from Other Localities," *Journ Acad Nat Sci Phila*, Ser 2, 7 331–334, Pl 26, Figs 17–20 1869

[2] Troxell, E L, "Palæolagus, an Extinct Hare," *Am Journ Sci*, 1 345–348 1921

A small amount of variation occurs between different specimens of the same tooth at comparable ages, but there is, nevertheless, a great deal of similarity in the series of specimens at hand, and we believe that all the material here described belongs to the single species *Palaeolagus haydeni* It is probable that several races or subspecies are represented, for much of the material lacks precise data of locality and formation Some of the specimens from the Peabody Museum which we have used in this study have been labeled by Troxell as belonging to the subspecies *Palaeolagus haydeni agapetillus* and *P h intermedius*, though most of them are assigned to the typical subspecies Since these three subspecies are separated by Troxell only on the basis of size, we have treated them together in considering the effects of age and wear on the characters of the teeth

The figures of the teeth were made by Grace Eager The enamel pattern of each tooth was drawn separately with a camera lucida from a point of view parallel to the length of the tooth

The youngest teeth in the lower jaws which we have examined are the third and fourth deciduous molars No trace so far has been found of either the first or the second deciduous lower molars

The most anterior milk tooth (DP_3), when first erupted, is made up of three principal transverse cusps, all of which rise into sharp

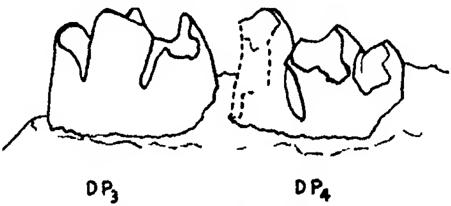


FIG 7 *Palaeolagus haydeni* DP_3 and DP_4 from inner side, × 12, anterior cusp of DP_4 somewhat broken Peabody Museum, No 13790

crests (Fig 7) Enamel surrounds all the cusps On the inner surface of the posterior lobe there is a small reëntrant angle of enamel (Fig 8) With wear the anterior cusp and the middle cusp become joined together near the middle of the tooth by a neck of enamel (Fig 9) At about the same time, sometimes earlier and sometimes later, the posterior and middle cusps also become joined near the middle of the tooth (Fig 10) With still further wear the posterior

cusp and the middle cusp become joined by enamel on the inner surface of the tooth, and thereby cut off an island of enamel (Fig 11) At this time the anterior cusp has almost entirely disappeared, being represented only by an enamel island toward the inner edge of the tooth, and by a shallow reëntrant angle on the outer edge of the tooth A somewhat different angle of wear on DP_3 is shown in

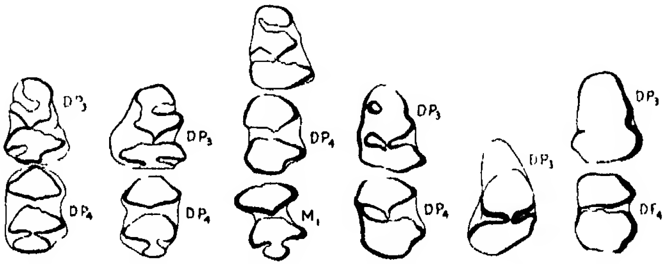


Fig 8 Fig 9 Fig 10 Fig 11 Fig 12 Fig 13

Figs 8-13 *Palaeolagus haydeni* Enamel patterns of lower deciduous molars × 6 Peabody Museum, Nos 13791, 12075, 13793, 12071D, 13794, 13795

Figure 12 where the anterior cusp has entirely disappeared, and the posterior and middle cusps are joined in the middle of the tooth In a slightly later stage of wear (Fig 13) both reentrant angles are much reduced, though enamel still completely surrounds the tooth In very late stages of wear (Pl XCIII, Figs 1-2) DP_3 has entirely lost the internal reentrant angle, but the external reentrant angle still persists In this very late stage of wear enamel occurs only on the outer border of the tooth and in the reentrant angle

The roots of the anterior deciduous molar (DP_3) penetrate deeply into the jaw, almost coming into contact with the root of the incisor When the crown of this deciduous molar has disappeared the roots remain in place for a short time The strong anterior root of DP_3 is directly in front of P_3 (Pl XCIII, Figs 3-4, text Fig 14) and on casual inspection might be mistaken for a more anterior tooth The posterior root of this milk tooth lies toward the outer side of the jaw between P_3 and P_4

The fourth deciduous molar (DP_4) at its first appearance (Fig 7) is made up of two principal transverse cusps, which rise into sharp crests A strong posterior lobe is attached to the posterior cusp

(Fig 8) Enamel surrounds all the cusps With wear the two main cusps become joined by enamel on their outer borders, and the tooth then has a rounded outline with an external reëntrant angle extending completely across (Fig 11) At this stage the enamel of the two pillars comes into very close contact in the middle of the tooth and gives an appearance almost of fusion, but in none of the specimens which we have examined is there an enamel connection at this place

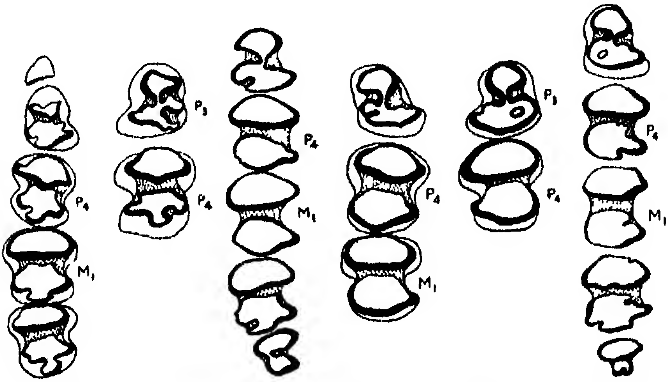


FIG 14 FIG 15 FIG 16 FIG 17 FIG 18 FIG 19

FIGS 14–19 *Palaeolagus haydeni* Enamel patterns of lower cheek teeth, × 6
FIG 14 Right P_3, P_4, M_1, M_2 U S N M, No 13558 In front of P_3 appears the broken anterior root of DP_3
FIG 15 Left P_3, P_4 U S N M, No 13559
FIG 16 Right P_3, P_4, M_1, M_2, M_3. Type of *Protolagus affinus* Walker Coll of Geo F Sternberg, No 26
FIG 17 Right P_3, P_4, M_1 U S N M, No 13560
FIG 18 Left P_3, P_4 U S N M, No 13561
FIG 19 Right P_3, P_4, M_1, M_2, M_3 U S N M, No 13562

In a late state of wear (Pl XCIII, Figs 1–2) the large external reëntrant angle of DP_4 is much reduced and extends only about halfway across the tooth In this stage of wear enamel is present only on the reëntrant angle and on the outer surface of the tooth

The two deciduous molars show a surprising correspondence in the details of their enamel patterns with the premolars which replace them The enamel pattern on the face of P_3 during a mature stage of wear is characterized by strong internal and external reëntrant

angles which nearly meet in the middle of the tooth Its milk tooth (DP_3) has a similar shape during one period of its wear In its mature condition P_4 has a strong external reentrant angle which extends completely across the tooth Its milk molar (DP_4) has similar characters during a part of its wear, and the milk molar even has for a time the posterior lobe on the tooth which is so characteristic of the early stages of wear on P_4

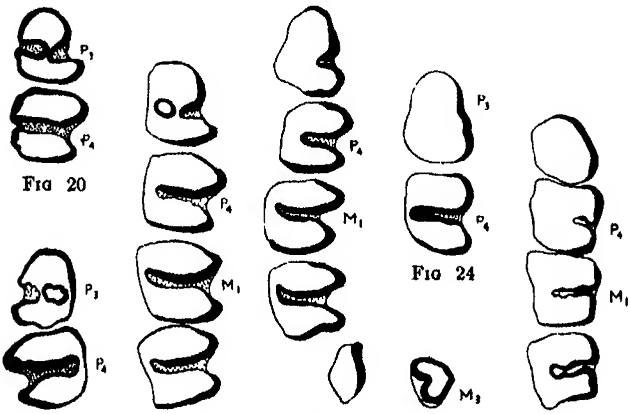


Fig 21 Fig 22 Fig 23 Fig 26 Fig 25

Figs 20–26 *Palaeolagus haydeni* Enamel patterns of lower cheek teeth, × 6
Fig 20 Right P_3 P_4 U S N M No 13563
Fig 21 Left P_3 P_4 U S N M, No 13564
Fig 22 Right P_3, P_4, M_1, M_2 Peabody Museum, No 13789
Fig 23 Right P_3, P_4 M_1, M_2, M_3 Type of *Archaeolagus striatus* Walker Coll of Geo F Sternberg, No 27
Fig 24 Right P_3, P_4 Peabody Museum No 13796
Fig 25 Right P_3 P_4, M_1 M_2 Peabody Museum, No 13797
Fig 26 Left M_3 U S N M, No 13565

At the age when the two milk molars are still in place, though much worn, the first two true molars are already in position (Pl XCIII, Figs 1–2), but the third molar has not yet erupted The fourth premolar erupts before the third, and may show considerable wear before the third deciduous molar is lost (Pl XCIII, Fig 3)

The third lower premolar, when it first erupts, consists primarily of two large transverse pillars, one anterior to the other and con-

nected broadly in the middle of the tooth by cement (Fig 14) When it is first erupted a line of enamel extends around each pillar and is thickest on the posterior border of the pillar The anterior pillar at its tip is invaded from in front by a broad shallow valley (Pl XCIII, Fig 3), which does not descend much below the summit of the cusp, and which therefore disappears shortly after wear begins on the tooth With only a small amount of wear the two pillars making up P_3 become connected in the middle of the tooth by an isthmus of enamel (Fig 15)

A small reëntrant angle develops on the inner surface of the posterior pillar of P_3 soon after wear begins on the surface of the tooth (Fig 14) This reëntrant angle enlarges with further wear (Fig 15), but soon again diminishes (Fig 16) The tooth at this stage has two internal reëntrant angles At the next stage of wear (Fig 17) the neck of the more posterior internal reentrant angle has become constricted (Fig 17), and the last stage of the angle is represented only by an island of enamel (Fig 18), which soon disappears (Fig 19) The whole process is passed through very early in the life of the tooth, and in all the later stages of wear on P_3 there is no trace on the posterior pillar of an internal reentrant angle

In some young specimens of P_3 there is a small indentation of the enamel on the posterior-exterior border of the posterior pillar (Pl XCIII, Fig 6), and this indentation, together with the internal reëntrant angle which is on the posterior pillar at this stage, produces a posterior lobe on the tooth similar to, but smaller than, the posterior lobes on P_4, M_1, and M_2 in their early stages of wear

On one unusual specimen of P_3 a small lobe is attached to the anterior face of the anterior pillar (Pl XCIII, Fig 6) This lobe does not extend far down the tooth, and would disappear after a brief period of wear

The general shape of P_3 during a considerable period of middle life is that of a compressed hourglass (Fig 19) With further wear the neck of the main internal reëntrant angle begins to constrict (Fig 20), and then closes off at the edge of the tooth, leaving an island of enamel (Figs 21–22) to mark the former position of the reëntrant angle With still more wear the island disappears and the external angle becomes reduced in depth (Fig 23) In very old age all the reentrant angles are gone and the tooth is roughly ovoid (Figs 24–25)

On the older specimens of P_3 the enamel is much thicker than

during the earlier stages of wear On the other molariform teeth also there is a similar thickening of the enamel in old age In the very oldest specimens of P_3 enamel is lacking on the inner surface, though it is still present as a thick plate on the outer surface

The fourth premolar erupts before the third, and its face shows a small amount of wear at the time when the third deciduous molar is lost (Pl XCIII, Figs 2 3) At its first appearance P_4 is made up of two independent transverse pillars, one anterior to the other (Fig 14) The two pillars are connected only by cement There is a posterior lobe on the hinder edge of the posterior pillar and this lobe is set off mainly by two posterior reëntrant angles, the inner one of which is the deeper With continued wear the posterior lobe becomes more prominent (Fig 15), mainly by the deepening of the outer one of the two reëntrant angles setting it off However, this posterior lobe exists during only a brief period of wear, for in the stage of wear represented by Figure 16 it has entirely disappeared

Each of the two pillars making up the slightly worn P_4 is surrounded by enamel, which is quite thick along the posterior edges of the pillars In older ages the enamel becomes thicker, but in the oldest (Figs 22–24) it is lacking on the inner surface of the tooth

The two pillars of P_4 maintain their distinctness over a long period of wear (Figs 15 20) Finally they become joined by enamel on the inner border of the tooth (Fig 21), and the tooth then has a somewhat rounded shape, with a deep external reëntrant angle The external reëntrant angle, when first formed, extends completely across the tooth With further wear it becomes shortened (Figs 22–24), and in the oldest specimen which we have seen (Fig 23) it extends only about one third of the way across the tooth

The history of the first and the second true molars is very much like that of P_4 Both M_1 and M_2 are in position and are very slightly worn at the time of the eruption of P_4 At their first appearance each of these molars is made up of two transverse pillars, one anterior to the other and connected only by cement When but slightly worn each of these teeth has a conspicuous posterior lobe (Pl XCIII, Figs 1–4) With wear the posterior lobes on these molars soon disappear (Figs 16 and 19), the lobe on M_1 goes before the one on M_2 The two pillars forming each molar eventually become united by enamel, so that, as in P_4, the teeth come to have deep external reëntrant angles With wear the depth of these reëntrant angles is

reduced (Figs 22–24) In the oldest specimen at hand (Fig 25) the reëntrant angles of M_1 and M_2 extend only about halfway across the teeth Throughout early and middle life enamel completely surrounds both M_1 and M_2, but in the oldest stages of wear enamel is lacking on the inner border of these teeth (Figs 22–23, 25)

The third lower molar (M_3) erupts at about the same time as P_3 (Pl XCIII, Figs 3–4), and at its first appearance it is made up of two pillars, one placed before the other in position, and each surrounded by enamel (Fig 19) An exceptional specimen of M_3 (Pl XCIII, Fig 5) has a posterior lobe like that of the other molars With wear the two pillars of M_3 become joined by a neck of enamel, so that there results a tooth (Fig 16) with an external reëntrant angle of enamel extending nearly across and nearly meeting a small internal groove At a later stage of wear M_3 is rounded and has a moderately deep external reëntrant angle (Fig 26) At this age enamel still completely surrounds the tooth In the oldest stages of wear M_3 consists of a single flattened plate with enamel only on its outer edge (Fig 23)

The order in which the several teeth erupt is not exactly uniform in the different lower jaws which we have examined Thus in Figure 19 a stage of slight wear on M_3 is associated with a more advanced stage of wear on the other teeth, whereas in Figure 16 an advanced stage of wear on M_3 is associated with a less advanced stage of wear on the other teeth

The very considerable changes which have been described above as occurring in the characters of the teeth of *Palaeolagus haydeni*, during the growth of the animal, have misled paleontologists into describing a number of species, genera, and even subfamilies from specimens which we believe belong to this one species

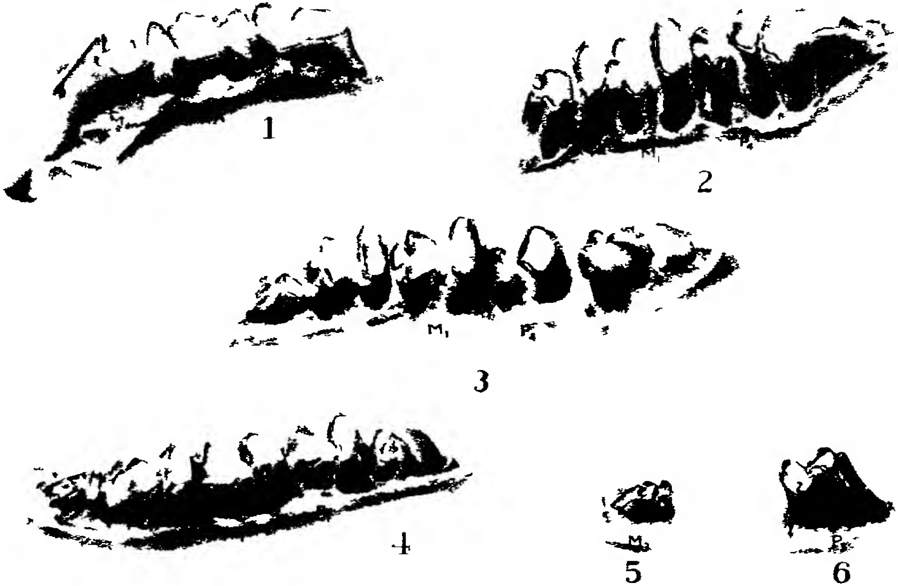
Cope [3] based his genus *Tricium* on the presence of the third posterior lobe on certain of the molars *Tricium avunculus*, *T leporinum*, and *T annae* seem all to be synonyms of *Palaeolagus haydeni*

Walker [4] based the subfamily Protolaginae on the presence of a second reëntrant angle on the inner face of P_3 We have been allowed by George F Sternberg to examine the type of *Protolagus affinus*

[3] Cope, E D, "Third Notice of Extinct Vertebrata from the Tertiary of the Plains," *Palaeontol Bull*, No 16 4–5 1873

[4] Walker, M V, "Notes on North American Fossil Lagomorpha," *The Aerend, Kansas State Teachers Coll Quart* (Hays, Kansas), *2*, No 4 238 1931

PLATE X



Lower cheek teeth of [illegible] 1–6. Peabody Museum Nos 13646 13647 13785 13787 13786 13788

Walker, on which the subfamily Protolaginae is based, the enamel patterns of the lower teeth of the type are drawn in Figure 16. The minor internal reentrant angle on P_3 of the type is only a temporary structure, for it extends but a short distance down the tooth beyond the present stage of wear. With a slight additional amount of wear this reentrant angle would disappear, as was noted by Walker himself. All the other characters of the teeth mentioned by Walker are those of a young specimen of *Palaeolagus*, and the specimen fits exactly into the series of growth stages of *Palaeolagus haydeni*. Furthermore, the skull shows no characters which would distinguish it in any way from an excellent skull of *Palaeolagus haydeni* which one of us has previously described.[5] It seems necessary, therefore, to regard *Protolagus affinus* as a synonym of *Palaeolagus haydeni*.

The species *Archaeolagus striatus* Walker[6] is based on a very old specimen, as is shown by the greatly worn teeth of the type, which is illustrated in Figure 23. None of the characters of the teeth of this specimen distinguish it from very old specimens of *Palaeolagus haydeni*, nor do there seem to be any characters of the skull which are distinctive. *Archaeolagus striatus* must, therefore, also be placed as a synonym of *Palaeolagus haydeni*.

UNIVERSITY OF MICHIGAN

[5] Dice, L. R., "Some Characters of the Skull and Skeleton of the Fossil Hare, *Palaeolagus haydeni*," *Pap. Mich. Acad. Sci., Arts and Letters*, 18 (1932): 301–306. 1933.

[6] Walker, *op. cit.*, p. 236.

A STUDY OF THE BAYPORT CHERT

FRED DUSTIN

FOR twenty-five years I have collected the cultural remains of the people who once occupied our state of Michigan, and my home county, Saginaw, has yielded over three thousand arrow points, with hundreds of drills, perforators, scrapers, leaf-shaped blades, and knives As the collection grew and interest increased, I observed that nearly all these artifacts were of a characteristic mineral in which the lines of growth or deposit were concentric The gathering of perfect pieces led to the saving of "rejects," turtlebacks, flakes, and fragments of odd form or showing hollows and crystalline cores From this it was but a step to the study of the material and to the wider field of its geological genesis and distribution

Chert, which mineralogists generally define as an impure flint, is of widespread occurrence, where certain types of limestone are found it exists either in concretions or in veins, sometimes merging into agate, chalcedony, true flint, or other form of silica It is usually gray, although occasionally black, becoming the basanite of the literature on gems, or, rarely, green, when it is called plasma It may be red, blue, pink, white, yellow, or brown, sometimes it is mistaken for jasper, although its true conchoidal fracture distinguishes it from that mineral, which shows an uneven surface when broken and carries a considerable percentage of elements other than silica

In a previous article [1] I have described certain materials used by the Indians in their lithic arts This paper is a more particular description of the Bayport chert found in the limestone most prominently exposed near Bayport in Huron County and in Arenac County, or on islands in Saginaw Bay In his geological paper on the Lower Peninsula, and on the map which accompanies it [2] Dr Carl Rominger defines this rock as "carboniferous limestone" It lies

[1] Dustin, Fred, "Materials of the Indian Lapidary in the Saginaw District Michigan," *Pap Mich Acad Sci , Arts and Letters*, 8 (1927) 11–22 1928.

[2] Rominger, C , *Geology of Lower Peninsula* (1876), *Geol. Surv Mich* , 3, Part I, 102, and map in pocket

beneath the coal measures, around which it forms an outward rim bounded by a line having near it Alabaster, West Branch, Reed City, Grand Rapids, Bellevue, Jackson, Holly, Otter Lake, and Caseville A later map[3] based on increased information somewhat modifies the area as given by Rominger Dr R A Smith, the present state geologist, defines the formation as "the Upper Grand Rapids or Bay Port (Maxville)"[4] and gives a somewhat detailed account of its occurrence, which he summarizes as follows "The Bayport limestone is the upper member of the Grand Rapids group of the Mississippian system It underlies a belt around the central Coal Basin excepting in the southeast where it has been largely removed by erosion The chief areas of exposure are in the vicinity of Bayport in Huron County, in Arenac County, and near Bellevue, Eaton County In Jackson County the Bayport limestone forms a capping on many of the pre-Coal Measure hills"

In Arenac County there are several exposures of the Bayport limestone, beginning at Point Au Gres, where it forms a ledge along the shore rising to a height of seven or eight feet From here the formation extends northwest along a low ridge, outcropping in eleven or twelve sections for a distance of eleven miles or more, it is sandy or cherty and contains many fossils About halfway between the villages of Omer and Au Gres the new paved highway, M-23, crosses a quarry site with good exposures of the rock In places the perpendicular face is from six to eight feet in height, thus giving a fair section The opening south of the road is about two hundred by three hundred feet, the one north is smaller and not so deep In some of the layers hundreds of chert nodules can be seen, many of fantastic forms, there also appear to be limestone concretions which have perhaps formed in the same manner that the chert has The rock is much shattered, partly from frost, and many of the chert nodules are broken and seem also to have deteriorated by weathering A visit to this place in the fall of 1933 gave me a good idea of the great supply of material for those artifacts which have been collected in the great Saginaw district and surrounding territory

The more important outcrops in Huron County are found in

[3] Leverett, Frank, and Taylor, Frank B, *The Pleistocene of Indiana and Michigan and the History of the Great Lakes, U S Geol Surv, Mon 53* (1915)

[4] Smith, R A, *Mineral Resources of Michigan for 1915 and Prior Years With a Treatise on Limestone Resources* (1916), Publ 21, Geol Ser 17, pp 162–185

the vicinity of Bayport, where it is exposed along the shore, on the islands west and northwest, and also at the Bayport quarries southeast, where the overlying soil is thin and where extensive operations have been conducted for nearly fifty years

At Charity Island there is a large exposure In Tuscola County two or three miles below the Grand Trunk Railroad bridge across the Cass River south of Cass City another outcrop appears which, though small, is of considerable interest From these places the aborigines secured their supplies of chert on which this study is based

In 1820 Henry R Schoolcraft said in his *Narrative Journal* [5] "In crossing the bay [Saginaw] we landed a few moments on Shawangunk [Charity] island which is found to be based on compact limestone, and contains embedded masses of Chalcedony and calcareous spar I also picked up, during the short period we remained, a lump of the argillaceous oxyd of iron, and some detached fragments of a coarse striped jasper"

Winchell states [6] that this limestone formation is seen under the water a long distance southwest of Little Charity Island, and that it outcrops on its northern, western, and southern shores, "but more extensively on the north side of Great Charity Island, where it rises about five feet above the water"

Rominger [7] describes the several strata exposed on the larger of the two islands, which is now officially known as Charity Island (The smaller one is now called Little Charity Island) He notices the numerous flint (chert) nodules and names the most important fossils

Lane,[8] who has reported at considerable length on the geological formations observed in Huron County, states that some of the limestone layers are filled with chert nodules and others with fossils, including corals and fish teeth He also says that on the shore of Charity Island facing Little Charity "there are low paving-slab out-

[5] *Narrative Journal of Travels through the Northwestern Region of the United States, extending through the Great Chain of American Lakes to the Sources of the Mississippi River In the Year 1820* (1821) p 99

[6] Winchell, A, *First Biennial Report of the Progress of the Geological Survey of Michigan, Lower Peninsula* (1861), p 101

[7] See page 119 of work cited in note 2

[8] Lane, Alfred C, *Geological Report on Huron County, Michigan* (1900) *Geol Surv Mich*, 7 Part II pp 105–112

crops of brown brittle dolomite with cavities, and the surface is strewn with chalcedony and other geodes, which have evidently been left by solution of the limestone that enclosed them "

Harlan I Smith,[9] the noted archaeologist, made many observations in the Bayport region He says "At the western limit of Wildfowl Bay is North Island, on the northern or highest part of which chert implements were found in all stages of manufacture, from the nodular masses occurring in the substratum of the entire island to the finished chipped points for spears, arrows, knives and similar objects Here were also found chips, flakes and other discarded fragments of the same material, — the waste from the processes of manufacture, — indicating the site of an ancient workshop " He notes similar conditions on "Heisterman" or Stony Island

Dr R A Smith [10] reviews previous reports and summarizes the available information, including that of Professor W M Gregory, whose *Geological Report on Arenac County, Michigan* (1912),[11] with its accompanying maps, has been useful in the preparation of this paper Dr Smith also describes the Bayport quarry, he gives a vertical section showing its several beds

Gregory's *Report* mentions several quarries in the limestone in Arenac County, with data on its appearances and commercial uses, whereas the sections given by Winchell, Rominger, Lane, and Smith have interesting details on the general character of the formation in the vicinity of Saginaw Bay, which are adequate for the purposes of the archaeologist

Winchell states in regard to the chert near or at Bayport "The flint nodules in layer D,[12] are bluish, of a fine, homogeneous structure and strike fire with steel, with great readiness They exist in large quantity " Rominger and Lane repeatedly mention "numerous nodules of chert," and R A Smith adds some facts on the "cherty limestone" in his "Treatise " [13]

This study is based on selected specimens, on which serial numbers have been placed They have been presented to the University of Michigan Museum, and may be of use to the archaeologist

[9] Smith, Harlan I , *The Saginaw Valley Collection*, Suppl to *Am Mus Journ* , Vol 7 (1901), No 12

[10] See page 226 of work cited in note 4

[11] *Mich Geol and Biol Surv* , Publ 11, Geol Ser 8, pp 47–58.

[12] See pages 101 and 102 of work cited in note 6

[13] Cited in note 4

In July, 1924, I visited the Bayport quarry, from my notes taken that day, together with later information, I give a brief description

The operations, in which was employed the best machinery for quarrying, transporting, and crushing the limestone, covered many acres of ground Steam shovels removed the overburden of soil, which was not thick, pneumatic drills pierced the rock for charges of dynamite, which broke it up to be lifted by a steam shovel into cars in which it was transported by a locomotive to the crusher, by which it was broken up and assorted into commercial sizes

My examination covered only a few hundred feet of the north face of the quarry, which was from ten to twelve feet high The rock first exposed (marked 1 in the series) is a sandy limestone about three feet thick, at the bottom of which there are one or two layers of limestone two inches in thickness, filled with simple fossil corals which look like sections of calamus root, most of them lying parallel with the bedding The replacement mineral of these fossils has the appearance of calcite, and the broken sections stand out in marked contrast to the yellow-gray matrix A more careful examination indicates that many of these corals are silicified, and when subjected to the hardness test and examined with a pocket lens are seen to be almost pure chalcedony Immediately below this fossiliferous layer is the cherty limestone containing thousands of chert nodules, or, as the quarrymen call them, "stones," some very compact with a glimmering luster when broken, others porous and of less purity Many are embedded in the broken rock, fair samples are the specimens 3-A and also 3-B, which is a small nodule in its limestone matrix Specimen 3 shows masses of brown rhombohedral crystals which I supposed to be calcite, but which later proved to be that form of magnesite called brown spar Calcite crystals do occur, however, and there seem to be variations in the crystalline secondary deposits, much silica in one locality and magnesia and iron in others, with occasional pockets of pyrite, zinc blende, or pure calcite crystals At the Bayport quarry there seems to be much brown spar, together with small masses of lean iron ore, probably limonite

At the base of the cherty limestone formation and resting on the shale beneath, a layer of very fine grained compressed limestone is seen which, when first exposed to the air, is of a warm gray color showing a decided umber tinge It breaks with a subconchoidal fracture, as it weathers, it grows lighter in color until it has the

appearance of chert even under the lens Since this is a valuable building stone, it is unfortunate that this layer is only ten or twelve inches thick For this reason it is not saved for building purposes unless there is a special order for it Specimens 4 are of this rock

The gritty shale under the compressed limestone, specimen 5, is a rather bright green, but that color does not seem to penetrate it more than a quarter of an inch, it may be due to iron, for throughout the limestone proper there are iron stains and ochery patches of mineral

The chert nodules seen were not large A great percentage of them were four inches or less in diameter, those of six inches and upward were very rare, and a quarryman of eight years' experience stated that eight inches was the limit As a rule, most of the concretions from the Bayport quarry are globular, while those at the Arenac quarry are frequently of eccentric shapes, resembling a pear, a heart, an hourglass, or other curious figures, some nearly round ones, collected on village sites, have been so deceptive in appearance as to be mistaken for tennis balls, larger ones have been called cannon balls by persons who have been deceived by their regular spherical outlines

I collected from Saginaw County village sites two hemispheres, one eight and one-half inches in diameter, the other eight, both very compact in texture A third, measuring six inches across, had six large flakes struck off, which, with the remaining unbroken piece, constituted two thirds of the original nodule, the seven portions were lying together where they had been buried in the earth on a village site, where flood waters brought them to light

My collection of nodules from prehistoric sites numbers twenty-five unbroken specimens, with an equal number slightly or considerably flaked

As to their formation, there seem to have been two processes of growth In the first there was a gradual filling of a cavity in the limestone by the deposit of silica on the lining, with the nodule generally becoming purer toward the center, not infrequently it has a core of translucent chalcedony or a small mass of transparent quartz crystals, but sometimes it leaves a hollow or vug, as though the siliceous solution had been exhausted In the second it would seem that the deposit began around some nucleus, organic or inorganic, and that a simultaneous process of dissolving out the limestone and

formation of the nodule occurred, both growing together with the cavity and its counterpart having the same form. Occasionally fossil casts are found in the chert, also real fossils, such as coral of several varieties, especially the simple forms.

The chert in the vicinity of Bayport is the type of mineral from which at least ninety per cent of the arrow points, drills, perforators, scrapers, and cutting blades collected in the Lower Peninsula were made. The color, texture, and concentric lines of formation, with certain other "earmarks" known to the close observer, indicate plainly their origin. There are variations from this type due to local conditions such as the presence of limonite in small quantities. Years ago I discovered a cache of leaf-shaped blades with distinct markings of an ocher shade. Later I found on a sand knoll swept bare by high winds a pile of flakes and chips, together with a hammer-stone that had evidently been used to strike off the flakes from nodules. This waste material was from the chert of which the blades in the cache had been made, the yellow stains, texture and lines of formation being identical.

Occasionally an artifact is collected of ashy black or of a dull bluish cast, but none originating from the Bayport limestone have been observed that were either a true black or a deep blue, although a number of both types in my collection were secured locally. Like the copper knives and beads from Isle Royale and the Upper Peninsula, the catlinite pipes from Minnesota, or the little cowry shells from the Florida coast, they are the fruits of travel or exchange, and are probably from Ohio or farther south.

Rarely a fine nodule, artifact, or flake will be found in which the ground mass is a pleasing gray, with almost pure white concentric layers alternating, thus giving a true agate somewhat like the gray Brazilian agates which the German lapidaries dye and polish and palm off on the unwary as naturally colored.

At a point on the Cass River near the line between Frankenmuth and Bridgeport townships, at the lower end of a high, steep bank, the aborigines had a canoe landing. In the bed of the river at this place I have collected at low water a pipe, a celt, a partly flaked nodule, and three or four of these gray agates; some distance back on the high ground of a village site two or three others were found which had been chipped. Aside from its archaeological interest, one is a most beautiful mineral specimen, its delicate and intricate lines

seem more like the handiwork of an artist than a work of nature I have presumed that these agates gathered from the river bed with the artifacts were lost in an accident, such as the overturning of a canoe or other casualty, and my good fortune in finding them was perhaps the ending of a story in which comedy or tragedy might have had a part

Chalcedony geodes from Charity Island have been mentioned and nodules of that material are not infrequent although, so far as noticed, they are not large, they furnish material for the smaller sizes of artifacts A few show delicate lines of formation, and are true agates, often with gray or white centers somewhat opaque Silicified fossils have been found on the Charity islands one, a bivalve with valves closed, seems to have been agatized, another, a small mass of cup corals, with the remains of other creatures, has an outer coloring of dark red, and shows drusy cavities in which the tiny crystals are also colored

At Point Lookout (Gravelly Point on the older maps) concretions of this nature are picked up, perhaps they had their origin in the reefs of the Charities, from which they were conveyed by ice or other natural agencies On the other hand, this point was the landing place for canoes crossing the bay from the eastward, and prehistoric remains are plentiful in the near vicinity, so some of the nodules and other products of the limestone may have been brought by human beings

Concerning the outcrop on Cass River, Dr Rominger makes the following statement [14] "Another locality where these lower beds of the carboniferous limestone series can be observed is on Cass River, 30 miles south of Caseville, in Town 13, R 11, Sect 16 ["16" is probably a misprint, it should be 6] At the farm-house of Mr W H Brown, situated close by the river bed, the water flows in rapids over the oblique edges of rock beds dipping at a moderate angle down stream Here we find a coarse-grained whitish sand rock Only a few steps below Mr Brown's house, the sand-rock ledges are overlapped by a bluish argillaceous limestone of a dull, earthy fracture and moderately soft It was from this rock that the Indians used to carve their smoking-pipes It contains numerous nodular concretions of Zincblende, or Druse cavities filled with this mineral, or with Brownspar or Dolomitspar The Zinc-

[14] See page 104 of work cited in note 2.

blende is mistaken by the inhabitants for Galena, and the same mistake occurs on the old maps of surveyors, lead ore being indicated as occurring in the vicinity of Cass River " He further speaks of several beds of limestone above this, and says "A hard, calcareous bed with flint concretions overlies them "

Many years ago I collected a large piece of chert approaching chalcedony in purity it had a peculiar metallic appearance and was yellow-brown Later it was shown to a mining engineer who pronounced it "sphalerite or zincblende with chert" and, on testing it for streak, obtained the characteristic brown powder of that mineral Since that time a few other pieces have been collected, so that it is probable that these blende-impregnated flakes came from the deposit studied by Rominger

As for the galena, it is not impossible that it occurs sparsely with the blende, as it does in some of the Mississippi River localities I have a small lump of this lead ore, also one of the blende, found not far apart near the bank of the Cass River at the same village site where the gray agates were collected They show the crystallization and the streak peculiar to those minerals, and in each the masses of crystals of the metallic ores are intermixed with other substances very similar to one another, perhaps indicating that they originated in the same rock formation, so that it is possible that a grain of truth may be buried in the lead legend of the Cass, which has been variously related and fantastically embellished Late in 1933 there appeared an article in a Saginaw paper [15] that reported "gold, zinc, lead and copper" as well as graphite to have been discovered by two local citizens of the "lead" neighborhood, one of whom was said to have smelted fifty pounds of rock and to have obtained "six pounds of a mixture of zinc, copper and lead, the zinc predominating " It is quite possible that the "gold" is pyrite and the copper (if any) a drift specimen or an oxidized artifact of prehistoric times A little knowledge of the genesis of graphite might be of use in determining the identity of a supposed deposit of that mineral

Another type of chert is that which is strongly colored by an iron oxide A short distance west of the town cemetery in James Township, Saginaw County, there is an area of two or three acres strewn with flakes, chips, rejects, and occasional arrow points or other artifacts, nearly all of a yellow-brown color, some darker than

[15] *Saginaw Daily News*, Wednesday, November 22, 1933

others, but all from the same lot of nodules It would seem that a canoe load of the raw material had been landed there and worked up into the finished weapons and implements This area, together with many acres around it, has been a prolific collecting ground, and the sandy soil is dotted with the fragments and refuse of manufacture but, with the exception of the brown chert mentioned, nearly all are of the common gray mineral The outer surface of the brown nodules is in no way different in color from that of the gray nodules, whereas the contrast of the interiors is striking

At the junction of the Tittabawassee and Shiawassee rivers there is a low flood plain that is occasionally covered by the high waters of spring This tract has been a fine collecting ground for local archaeologists, and of hundreds of chert artifacts secured a large portion are marked with dendrites from iron or manganese, the mossy figures being much the same as those of the moss agates from Wyoming If the material were a translucent chalcedony instead of an opaque chert the resulting gem would be a fine one These dendritic markings must have been acquired from repeated soakings of river water carrying iron or manganese, or from the wet soil itself

Some archaeologists have stressed the existence of "workshops", that such existed there can be no doubt, but every village site of more or less permanent residence that I have seen was a workshop where arrow points and all other articles of chert were made We can picture the Indian of the Saginaw country making a trip in his canoe to Au Gres, to Charity Island, to Bayport, or to the reefs of the Cass, gathering his cargo of nodules with perhaps some curious fossils and beautiful crystals or such shining minerals as pyrite or blood-red jasper, then in his little bark returning to the home wigwam where the rivers meet

Here he buries the rounded stones of flint, for he well knows that moisture facilitates their working, and later, in his leisure hours, he digs out a few and with his hammerstone strikes off flakes of suitable size If time permits, he chips them into leaf-shaped blades and again buries them until necessity requires, when they are again unearthed, the chipping tool comes into play, and arrow point, drill, or blade is fashioned with speed and skill

Perhaps disaster overtakes our red worker or death comes, and his hoard of blades is forgotten Many generations come and go and a new race possesses the land Some of these newcomers are

sneering, some are indifferent, some mildly curious, but finally one comes whose visions of the past are tinged with reverence for those who have gone before From time to time his feet tread upon their ashes, and he gathers from their long-deserted haunts the pipe and the stone hatchet, symbolizing their peace and their war On the edge of that sand knoll which the wind has bared he sees a little pile of chipped blades and soon uncovers the cache so long hidden He has come to the end of the story

SAGINAW, MICHIGAN

A STUDY OF UNDERGROUND WATERS BEARING ON THE SOURCE OF "BIG SPRING," SCHOOLCRAFT COUNTY, MICHIGAN

O FLOYD POINDEXTER

"BIG SPRING" is located in Schoolcraft County, Michigan, on the west side of Indian Lake about eight miles in a northwesterly direction from the city of Manistique It is reached by means of a good gravel road (M–149) intersecting U S –2 at a point approximately eight miles west of Manistique and running north and east for about four and one-half miles to the site of the spring In 1929 the Palms Book Land Company of Detroit deeded to the state the 40 acres upon which the spring is located, together with an adjoining lot comprising 49 40 acres The indenture provides that this grant is "to be forever used only as a public park bearing the name Palms Book State Park" Additional descriptions adjacent to this gift, deeded to the state through tax delinquency, amount to 327 40 acres, bringing the total acreage of state-owned land surrounding the spring to 417 30 acres, with a frontage of 3,000 feet on Indian Lake

Big Spring (see Pl XCIV) is a roughly oval pool, the surface dimensions of which are stated to be 300 by 175 feet The sides of the depression slope abruptly to a depth of 40 feet, where the water enters under strong hydrostatic pressure, roiling the sandy bottom so much that a pronounced boiling effect plainly visible from the surface is obtained The spring has a scenic location at the edge of a coniferous swamp, with the verdant growth adding much to the charm and beauty of the surroundings The water is of an unusual emerald green, due probably to the luxuriant growth of aquatic vegetation clothing the sides of the pool and draping the submerged trunks of fallen trees

According to legend, the Indians named the spring Kitchitikipi, in memory of the young chieftain of that name who went to his death in the icy waters in an attempt to satisfy the vain caprice of his

ladylove, who insisted as a test of devotion that he catch her as she jumped into the canoe from an overhanging bough Indian lore naturally held the "great spring" to be a manifestation of the power of "Gitchi-Manitou," the "Great Spirit," who caused the crystal waters to well up from unknown depths

Old residents tell one that the source of Big Spring is Lake Superior, but, since the spring lies at a higher elevation than the great lake to the north, this theory is obviously not in accord with natural observed phenomena, nor is it necessary to assume such a vast reservoir as Lake Superior in a search for the ultimate source of this scenic wonder The great swamp of the Manistique River (Seney Swamp) and the numerous lakes in the Hiawatha National Forest region furnish to the underground drainage sufficient quantities of water under ample hydrostatic pressure to form any number of springs similar in character to Big Spring Many lakes in northwestern Schoolcraft County and in adjoining parts of Alger and Delta counties have no surface outlet, but contribute their surpluses to the subsurface flow

In the fall of 1932 a water well was drilled in the Palms-Book State Park about one hundred feet northwest of the spring This well was put down because of an unsatisfactory test of the water of the spring for drinking purposes Later it was found that the spring had been sampled at the edge, where it was exposed to contamination Subsequent tests taken from the center of the pool proved that pure drinking water could have been obtained by piping from the deeper parts

The driller's log and samples furnished by Richard Kiney, well contractor, imparted valuable information regarding the character of the formations penetrated by the drill From the surface to a depth of 29 feet soft clay was encountered, below this 8 feet of hardpan consisting of a mixture of gravel, sand, and clay was reported, followed by 10½ feet of quicksand and hardpan, with fine sand and gravel at a depth of 55 feet 8 inches At this depth the water enters very freely and rises to a height of 48 feet in the pipe When examination of the well samples and log showed the water in the well to come from a bed of sand and gravel at a depth of 55 feet 8 inches, it was considered probable that the water forming the spring is derived from the glacial drift and that it comes down under the thick lake clays known to underlie the Seney Swamp The record of the well,

PLATE XCIV

View of the "Big Spring," Palms Book State Park, near Manistique, Michigan. (Photograph by Department of Conservation, State of Michigan.)

which gives 29 feet of clay at the surface, would lend support to such a theory

The depth at which water was encountered in the well and the amount of head present suggest that the well taps the same stream of water that forms the spring Chemical analyses of samples from both the well and the spring confirm this suggestion, since the characteristic feature of both samples is the presence of relatively large amounts of calcium sulphate The sample from the well contained 1,180 parts per million of SO_4, and the sample from the spring showed a sulphate content of 532 parts per million This large discrepancy in amount of sulphate was at first puzzling, since waters obtained from the same source at so close an interval should be very nearly similar This difference is, however, logically explained by the fact that the spring sample was obtained near the edge of the pool, where the normal waters arising from the bottom are diluted by the soft water draining into the spring from the surrounding swamp Mr John Hepler of the Michigan Department of Health suggests that there may be stratification of water in the pool, owing to variation in specific gravity

Results of analyses of water from the spring and from the well at the pavilion are even more striking when compared with those of waters from other sources Sixteen samples collected by S G Bergquist, from Michigan State College, from as many different lakes, streams, and rivers in various parts of Schoolcraft County, indicate a maximum sulphate concentration 56 8 parts per million at the south end of Indian Lake, but the average sulphate content of these samples was only 17 8 parts per million (Table I) Similarly, nine samples from wells drawing their water from the glacial drift gave a maximum SO_4 content of 54 parts per million and an average of 15 5 parts per million (Table II) Shallow waters in the Niagaran limestones were not greatly dissimilar, seven samples had an average SO_4 content of only 8 3 parts per million (Table II, Anal 11–17)

In the city of Manistique there are many flowing wells which form the original water supply of the city, the depths of which indicate that the water probably comes from the lower part of the Niagaran Series The sulphate content of these wells varies from 425 to 480 parts per million (Table II, Anal 18–20) One deep well at Whitedale showed 870 parts per million (Table II, Anal 21)

A well 117 feet deep in Blaney Park encountered the following

TABLE I

ANALYSES OF RIVER, LAKE AND SPRING WATERS IN SCHOOLCRAFT COUNTY *

(Samples collected by S G Bergquist)

Source of sample	SiO_2	Fe_2O_3	Ca	Mg	Na+K	Cl	SO_4	HCO_3	Total solids	Hardness as $CaCO_3$
Big Spring	17.6		230.5	21.0	3.4	6.5	532.0	130.0	878	700
Driggs Lake	2.4	0.23	24.0	5.6	Tr	4.0	4.9	89.5	88	80
Driggs River	5.6	0.74	19.5	5.0	5.0	4.0	4.9	85.0	82	70
Fox River, West Branch at Seney	6.4	1.02	16.5	4.5	4.3	4.0	7.2	72.0	78	60
Gulliver Lake	8.8		30.0	13.8	3.2	4.0	10.5	149.5	154	130
Indian Lake, South End	15.2	Tr	47.0	10.0	2.3	3.0	56.8	122.0	214	168
Indian River at M-94	8.8	Tr	45.0	9.3	4.1	3.5	56.0	118.0	188	150
Indian River, Sec 34 T 44 N R 17 W	12.8		27.0	7.1	5.7	4.0	6.5	113.5	124	95
Intake Park	7.2	0.31	41.0	8.2	Tr	4.0	43.2	107.0	162	135
Lake Michigan	5.6		33.5	11.2	8.0	5.0	15.1	135.0	154	130
Manistique River Sec 24 T 45 N R 13 W	8.0	0.34	28.0	6.6	8.9	4.0	25.0	93.5	134	100
McDonald Lake	4.8	0.23	29.0	11.9	Tr	4.0	15.8	123.0	132	120
Murphy River	7.2		27.0	8.2	2.7	3.0	14.8	107.5	116	100
Ross Lake	4.0	0.45	18.5	5.2	Tr	4.0	4.0	72.5	76	68
Smith Lake	4.0	0.34	5.0	1.5	4.3	4.0	6.5	20.0	36	18
Thompson Spring	6.4		21.5	13.8	9.6	4.0	5.9	125.5	133	110
Thunder Lake	4.0		21.5	7.3	7.6	4.0	8.8	99.0	106	82

* Analyses by Miss Alice Exworthy Michigan Department of Health

materials sand, 15 feet, hardpan, 35 feet, clay, 10 feet, limestone, 20 feet, "black rock," 10 feet, and blue shale, 25 feet

Analysis of this water indicates a sulphate content of 1,368 parts per million (Table II, Anal 22), and the water is said to come from the shale Since the Niagaran of the Upper Peninsula is entirely devoid of even thin shale beds, it is probable that the shale corresponds to that logged as Cataract in the record of the well drilled for oil at Seul Choix Point The drill cuttings at this depth are shale and shaly dolomite, which contain abundant calcium sulphate in the form of brownish anhydrite It is not impossible, however, that the shale in the well at Blaney marks the top of the Ordovician, which, as shown by the samples of the Seul Choix well, contain even more abundant reddish gypsum and anhydrite

The marked difference in mineral composition of the samples obtained from the Big Spring and the adjacent well and of those

TABLE II

ANALYSES OF WELL WATERS FROM SCHOOLCRAFT COUNTY *

(Parts per million)

Drift waters

Analysis	SiO_2	Fe_2O_3	Ca	Mg	Na + K	Cl	SO_4	HCO_3	Total solids	Hardness as $CaCO_3$
1	3.2		31.5	8.8	Tr	4.0	21.0	108.5	128	112
2	29.6	19.4	32.5	7.5	12.2	3.0	4.9	157.0	186	110
3	12.0	1.3	64.0	15.7	16.9	20.0	54.0	215.0	304	220
4	2.4	Tr	4.5	2.2	Tr	4.0	8.9	5.5	28	25
5	9.6	0.34	15.5	7.2	31.7	11.0	1.3	113.5	156	68
6	4.8		52.5	16.8	Tr	4.0	12.8	224.5	204	200
7	4.8	0.34	16.0	11.2	[illegible].0	20.5	25.7	14[illegible]	270	98
8	7.2	Tr	14.0	10.5	25.3	5.0	3.6	148.5	142	78
9	4.8	0.63	21.5	8.4	Tr	3.5	7.5	95.0	98	90
10	15.2	1.83	366.0	100.0	14.0	11.0	1180.0	134.0	1752	1300
Limestone waters										
11	4.0	0.74	54.0	30.0	Tr	4.0	9.9	293.0	268	258
12	5.6	Tr	45.5	21.2	2.9	5.0	5.2	234.5	184	200
13	7.2	0.63	42.5	21.6	Tr	1.0	9.9	219.0	194	195
14	8.0	0.51	45.5	22.0	1.4	3.5	6.6	239.0	208	204
15	6.4		40.0	20.0	9.2	3.0	4.6	235.0	194	182
16	7.2		43.0	20.4	3.9	3.0	5.3	232.0	198	190
17	5.6	0.34	45.5	19.9	9.6	10.0	17.0	204.5	232	195
18	11.2	1.2	173.0	62.0	46.8	100.0	125.6	249.0	960	680
19	6.4		126.5	51.8	20.2	6.0	440.0	144.5	726	540
20	8.8	0.17	170.5	59.6	43.8	75.0	480.0	192.0	928	668
21	9.6	Tr	340.0	44.8	Tr	5.0	870.0	157.0	1346	1050
22	8.8	0.51	560.5	43.2	5.5	16.5	1368.0	172.5	2160	1580

* Analyses by Miss Alice Fxworthy, Michigan Department of Health

obtained from surface waters, drift wells, and shallow rock wells, as opposed to the similarity of the State Park waters to those of the deeper formations, suggests that Big Spring may have its source of supply at or very near the base of the Niagaran, if not in Cataract or Ordovician strata. The Lower Niagaran strata could, possibly, obtain a sulphate content through waters circulating at the base of the series in contact with Cataract strata. No gypsum or

other sulphates are present in the Niagaran section from the well at Seul Choix, nor can any be observed in a set of samples from one of the old water wells at Manistique

An argument against the Lower Niagaran rocks as a source of supply for Big Spring is the fact that no flowing wells are found in Niagaran strata outside the area covered by the outcrop of the Manistique formation, although numerous flows in this belt extend across Schoolcraft County from Hunt Spur in Mackinac County to the village of Thompson

It appears that the dense, platy, and cherty dolomites of the Manistique formation may act as the confining cap rock for the Lower Niagaran aquifer, and, furthermore, it is probable that there is a loss of head in passing northward toward the Niagaran escarpment, since the surface elevation increases about one hundred feet and the lower beds of the Niagaran are truncated by the great preglacial valley to the north, probably at a considerably lower elevation On the other hand, the Cataract and Cincinnatian rocks forming belts to the northward and underlying a continually rising surface undoubtedly have the requisite artesian conditions, as is proved by the well at Blaney

Aerial photographs show a cluster of six or more sharply defined depressions about one mile south of Big Spring These have not been visited on the ground, but their appearance under the stereoscope is very similar to that of many of the sink holes of Presque Isle County

It is probable that the glacial drift at Big Spring is not much thicker than the 55 feet 8 inches penetrated by the well A well drilled on the shore of Indian Lake about three and one-half miles southeast of the spring found bedrock at 70 feet, and a well about two and one-half miles southwest encountered rock at 20 feet Scott[1] reports an outcrop of limestone about one mile north of the south end of Indian Lake, but at Parker's resort at the south end of the lake it is 103 feet to rock

It has been suggested by several geologists that the spring was formed as a result of a cave or fault in the underlying limestone formations In view of the fact that there are no pure limestones in the lower part of the Niagaran or in the formations below the Ni-

[1] Scott, I D, *Inland Lakes of Michigan, Mich Geol and Biol Surv*, Publ 30, p 281

agaran, it is possible that cave-ins may have resulted from the solution of beds of gypsum in Cataract and Cincinnatian strata. Slumping of the overlying strata would then form an avenue of easy and rapid passage of the calcium sulphate waters rising under hydrostatic pressure, with the shales at the top of the Cataract formation constituting the cap rock to complete the requisite artesian conditions.

Michigan Geological Survey
Lansing, Michigan

GEOLOGY OF THE HART OIL FIELD

C HAROLD RIGGS

THE Hart Oil Field is a small producing area near the center of Oceana County about thirty miles north of Muskegon, Michigan Though the field is not of great commercial importance, some of its features are of geological interest Oil occurs in dolomitic cavities near the top of the Traverse limestone Accumulation is due primarily to differences of perviousness in the reservoir rock and, to a lesser extent, to small structures

HISTORY AND DEVELOPMENT

The first well was drilled in August, 1932, by Edward DuVall on the Oscar Weirich property in the NE ¼ of SE ¼ of Section 31, T 15 N, R 16 W Oil was encountered in the top of the Traverse limestone at approximately 1,900 feet The oil filled up rapidly in the hole and flowed into tanks under considerable pressure When shut in, the well showed a pressure of 50 pounds to the square inch at the casing head

During the next few days the well flowed by heads, making from 40 to 80 barrels of oil at each flow The Napth-Sol Refining Company of Muskegon agreed to purchase the oil A total of 329 barrels was produced before the well was shut down because of legal difficulties over the title of the property

Excitement over a new oil discovery ran high in Hart and Muskegon, and leasing costs were more than later developments warranted However, the next two wells drilled northwest and southeast of the Weirich well encountered water and no oil in the Traverse limestone The first of these wells, the A S Cochran Hannum No 1, was drilled to the "Dundee," where water was encountered at 2,407 feet and the well was abandoned

In March, 1933, Flanigan and Voorhees started a well on the E Mitchell property in the SE ¼ of SE ¼ of Section 36, T 15 N, R 17 W, one mile west of the discovery well "Pay sands" were encountered in the Traverse limestone from 1,904 to 1,907 feet, and

oil filled up 1,500 feet in the hole The well was treated with Dowell acid and produced approximately 25 barrels of oil daily A second acid treatment failed to increase production (Fig 28)

Meanwhile the Oscar Weirich well had been reopened It was found that there was 1,100 feet of salt water in the bottom of the hole, with heavy viscous oil on top When this water was bailed down to 800 feet the well made a small flow of oil After each flow the water would fill up in the bottom of the hole and the well could be made to flow only by keeping the water bailed down The well was put to pumping soon afterward It has since made a little oil and much water

In July, 1933, the E Mitchell well was treated with acid for the third time When reopened it flowed and soon filled all available storage A week later, when more tanks had been installed, it produced 711 barrels of oil on a 24-hour test Development has proceeded rapidly since then and at the present time (March 1, 1934) there are 14 producing wells, 8 dry holes, and 5 uncompleted wells in the general area

STRATIGRAPHY

The surface formations at the Hart Field are glacial moraine and outwash plain The moraine tends northwest to southeast through the western part of the field Surface elevations vary from 860 feet above sea level on top of the moraine to 710 feet on the comparatively flat outwash plain The glacial drift is from 400 to 500 feet thick and consists of alternating layers of clay, sand, and gravel The wells drilled around the base of the moraine encounter artesian water in the top of the second sand layer Evidently this sand layer has a connection with surface waters to provide a head somewhere in the moraine Clay underlying the sandy outwash plain forms a seal above the water-bearing horizon

The field lies almost wholly within the belt of Marshall outcrop, but close to the contact with the Grand Rapids series to the southeast One well drilled in the southeastern part of the area encountered eight feet of shale and gypsum, presumably of the Grand Rapids series The Napoleon sandstone in this well is thinner than in other wells to the west, and the occurrence of the Grand Rapids series here may be due to its deposition in a channel of erosion in the top of the Upper Marshall formation

The Napoleon sandstone is composed of medium to fine light gray sandstone, with an occasional bed of gray shale Thickness varies from 50 to 85 feet, increasing to the southeast in the direction of regional dip The sandstone is abnormally thick in the southwestern corner of the area, where hills probably stood out in the preglacial land surface

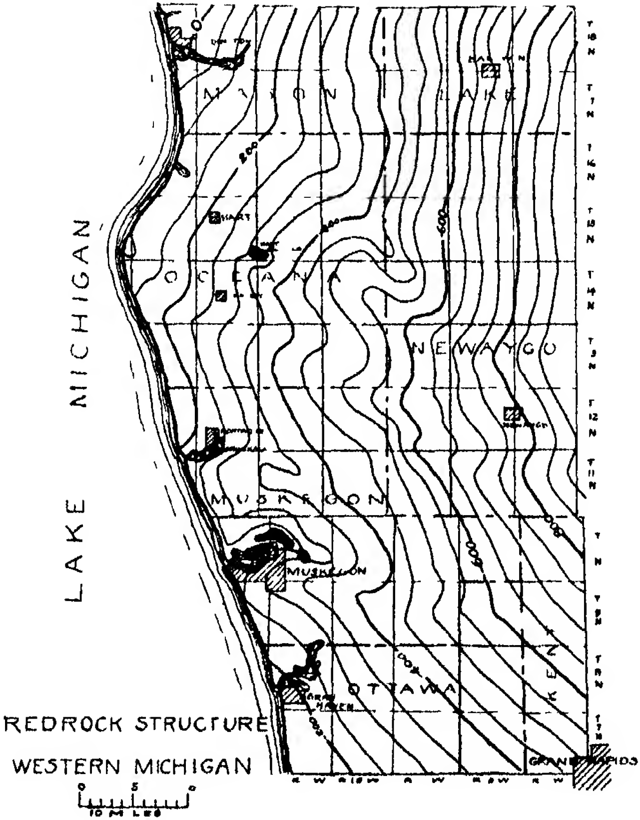
The Lower Marshall formation is composed of fine dark red sandstone and sandy shale The absence of some of the lower beds in the western part of the area suggests an overlap with deposition on an irregular land surface Thickness varies from 40 to 70 feet

The Coldwater formation consists of light gray shales and argillaceous limestones About 250 feet below the top of the formation is a calcareous zone with beds of argillaceous limestone grading laterally and vertically into shale Locally these limestones are dolomitic or contain gypsum From 500 to 550 feet below the top of the formation there is another calcareous zone The top of this zone is marked by a thin bed of red calcareous shale called "Red Rock" Below the top bed occur several layers of reddish limestone

The shales below these limestones have been termed "Ellsworth"[1] They do not differ much from those above, but grade downward into shale of a more greenish cast There have been sandstone layers encountered in different wells throughout the area Locally these sandstones are called "Berea," although they are evidently sandstone lenses in the shale and may represent reworked Berea material The interval between these sandstone layers and known horizons varies greatly, and it is probable that they are not the same bed, but occupy different stratigraphic positions A dolomitic sandstone from the southeastern part of the field is very dense and fine grained and contains small quantities of oil

Interpretation of well logs may indicate an erosional unconformity separating the Antrim from the overlying dark shales It is possible that irregularities in thickness may be due to lateral gradation at the base of the Ellsworth The upper part of the Antrim is soft, light brown shale, the lower part is dark brown to black and is more calcareous The base of the Antrim is marked by a slight unconformity Pyrite concretions near the base of the Antrim may have been a residual deposit from weathering of Traverse shales

[1] Newcombe, Robert B, *Oil and Gas Fields of Michigan*, Geol Surv Mich, Publ 38, Geol Ser 32



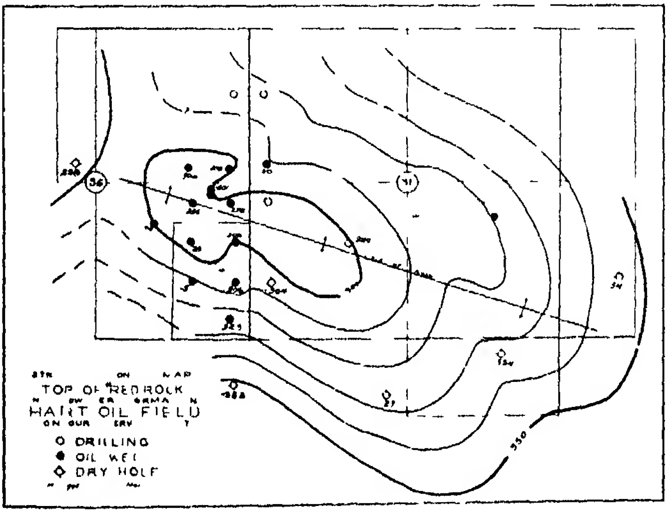
MAP 39

The top of the Traverse formation is a gray shale containing considerable pyrite The shale becomes more calcareous with depth, grading into limestone from 40 to 80 feet below the top of the formation Pore spaces in the top of the limestone contain oil above low folds and water on their flanks From 40 to 50 feet below the top

of the limestone there is a water-bearing zone, which probably corresponds more nearly with Upper Traverse pay horizons elsewhere in western Michigan

STRUCTURE

The Hart Oil Field is located near the western rim of the Michigan Basin where the rocks dip southeast twenty to thirty feet per mile It lies at the head of a broad syncline between a pronounced fold to



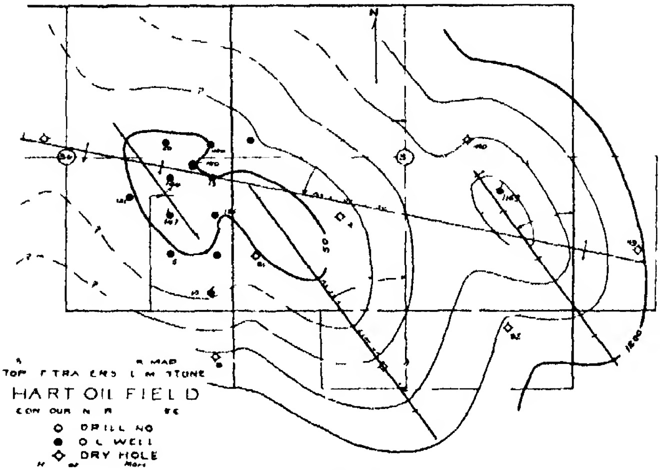
MAP 40

the northeast and a suggestion of a fold in the southern part of Oceana County (Map 39)

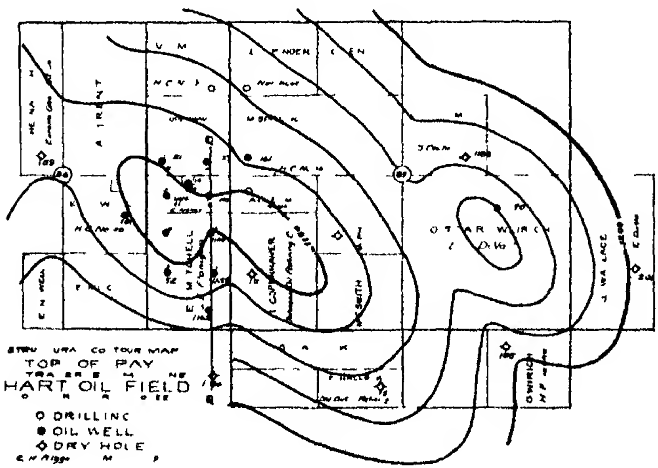
Detailed structure contour maps of the field show two important features a modified nose trending NW–SE and smaller echelon folds with axial directions N 35° W (Maps 40–42) There is some evidence to indicate that the nose may have been formed prior to Marshall deposition This evidence is listed as follows

1 Total thickness of the Lower Marshall is less over the nose and increases off-structure,

2 Lower beds of the Marshall are absent on top and west of the fold (evidently some topographic feature acted as a temporary barrier to westward encroaching seas),


HART OIL FIELD
DRY HOLE

Map 41

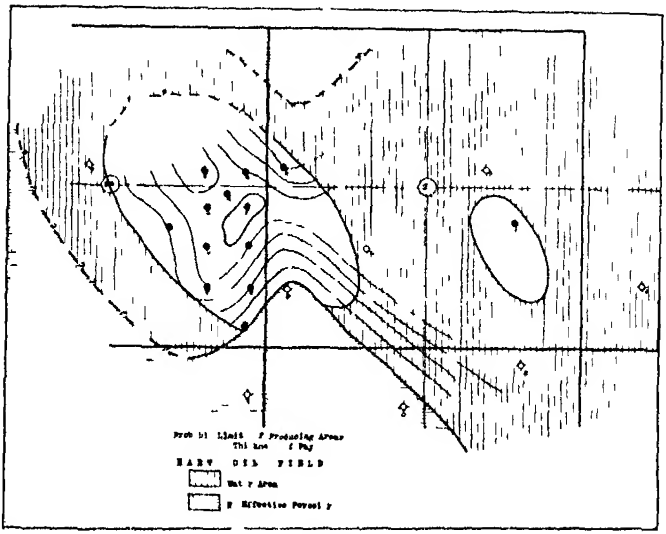

TOP OF PAY
HART OIL FIELD
DRILLING
OIL WELL
DRY HOLE

Map 42

3 Structure on the top of the Lower Marshall formation does not correspond to nose structure of lower beds,

4 A nose is shown when the structure on top of the Lower Marshall is subtracted from that of the lower beds (structure of the lower beds would indicate deformation due to both periods of folding whereas structure on top of the Lower Marshall would show only folding of the later period)

That this folding of the nose may be due to differential settling over deep folds or coral reef is suggested by a thickening off-structure of the upper part of the Coldwater formation



MAP 43

The axial directions of echelon folds shown by contours on the lower formations correspond in general with the folds of the Marshall formation These folds were probably caused by post-Marshall movements effective over most of Lower Michigan

RESERVOIR CONDITIONS

Though the nose and the small folds seem to govern the local distribution of oil, their size and extent do not appear to be sufficient to have been the primary cause of accumulation Rather it is more

probable that up-dip migration of oil above salt water was halted by a lack of perviousness in the reservoir rock Wells show a decrease in the amount of perviousness and thickness of pay from east to west across the area (Map 42) The limit of the area of no effective porosity to the west of the producing area is rather indefinite

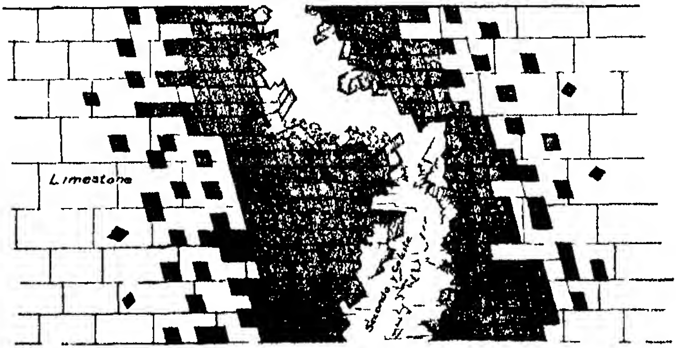


FIG 27 Section to illustrate nature of dolomitic cavities

owing to lack of information Its existence is indicated by a thinning of pay to the west and by the absence of pay in a well drilled one mile west of the field

The thickness of the porous zone containing oil seems to vary with the proportion of dolomite to limestone in the section The pore spaces and small cavities are probably related to the formation of the dolomite In a section along the line B–B′ (Map 42) the thickness of dolomite and the thickness of pay increases above the structure, but this relationship does not exist throughout the area Map 43 shows the area of no effective porosity up on the side of the structure Wells off structure east of the field indicate an increase rather than a decrease in perviousness, and water fills up rapidly in the hole The dolomite seems to be concentrated near the top of the Traverse limestone and porosity in the lower water-bearing zone is evidently not due to dolomitization There is no evidence to indicate that the dolomite is interbedded with the limestone It probably exists as nests, chimneys, or zones in the limestone

Figure 27 illustrates the author's conception of the nature of

these dolomitic cavities No cores of the pay have been taken, and our knowledge, based only on drill cuttings, must necessarily be very incomplete It is probable that these cavities are not very large, although the larger cavities and crystals would be broken up by the drill Drill-cuttings show rhombohedral crystals of dolomite lining the openings Rarely these cavities are lined with black carbonaceous material Sometimes they are partly or completely filled with crystals of secondary calcite Crystals of pyrite are associated with the secondary calcite Sometimes the cavities are partly filled with sand and other clastic material Back from the edge of the openings the material is coarsely crystalline dolomite Samples from just above and just below a dolomitic zone reveal sharp rhombohedrons of dolomite in dense limestone No fossils have been found in the limestone or dolomite It is assumed that these cavities are more or less connected and form the reservoir in which oil has accumulated Probably the greatest effect of acid treatment is to remove the secondary calcite and to open channels between cavities

It would seem probable that this material was deposited as calcium carbonate with a small amount of magnesium carbonate The overlying shales and undolomitized limestones below contain varying amounts of magnesium Leaching of calcium carbonate by downward-moving acidic waters would increase the proportion of magnesium carbonate to a point at which dolomite could be precipitated Worm trails or cavities left by the solution of shells by organic acids may have provided the avenues of migration The absence of fossils in the limestone as compared with the overlying shale could be explained more easily by their subsequent solution than by a supposition that the fauna did not exist during limestone deposition, but suddenly appeared with the argillaceous sediments The leaching of calcium carbonate would enlarge preexisting avenues of migration Smaller, disconnected openings may be due to the decrease in volume accompanying dolomitization It may be assumed that dolomitization would commence at the openings and work outward The extent of this action would then depend primarily upon the perviousness of the original material It has been noted that the limestone associated with the dolomite is less dense than undolomitized portions Calcium carbonate removed by leaching would be carried downward into preformed cavities and deposited as secondary calcite Close association of secondary calcite and

secondary pyrite would seem to indicate that they were precipitated from the same solution under similar conditions It is supposed that leaching commenced while the material was still unconsolidated on the sea bottom The concentration of dolomite near the top of the Traverse limestone and its association elsewhere with gypsum or anhydrite suggest that the original dolomitization took place in shallow water where deposition was irregular Later concentration of dolomite may have occurred during elevation and erosion

DRILLING AND PRODUCING PRACTICES

Drilling in the Hart Oil Field is done with either standard rigs or drilling machines Drilling time varies from twenty to forty days The common practice is to drill one well to each ten acres in the proved area, but this practice is not always followed The thick drift (400 to 500 feet) makes the driving of pipe difficult Some wells drilled on the moraine have encountered boulders, necessitating skidding of the rig Ten-inch drive pipe is landed on top of the Marshall formation to shut out fresh water and caving sands Brackish mineral water is encountered in the Marshall formation and is shut out of the wells with eight and one-quarter inch casing set in the top of the Coldwater shale Six and five-eighths casing is usually set in the calcareous shales above the Traverse limestone to prevent caving from above

A few wells have flowed by natural pressure when drilled into the pay formation near the top of the limestone The volume of gas in the wells is small, and it would seem that water pressure behind the oil is the greatest force causing the wells to flow With low perviousness and without uniform porosity it is assumed that the wells nearest the oil-water contact would show the greatest pressure Production records of two edge wells tend to verify this assumption

Tubing is usually set on packer above the pay horizon and the wells are treated with 1,000 gallons of Dowell acid Because of the tight pay considerable pressure is required to force the acid back into the formation, where it will open channels between cavities Sometimes two or three attempts are made before the well is successfully treated The acid treatments increase production from 10 to over 1,000 per cent (Fig 28) Drilling and treating costs average close to $5,000 00 a well

After acid treatment the wells are usually swabbed and cleaned

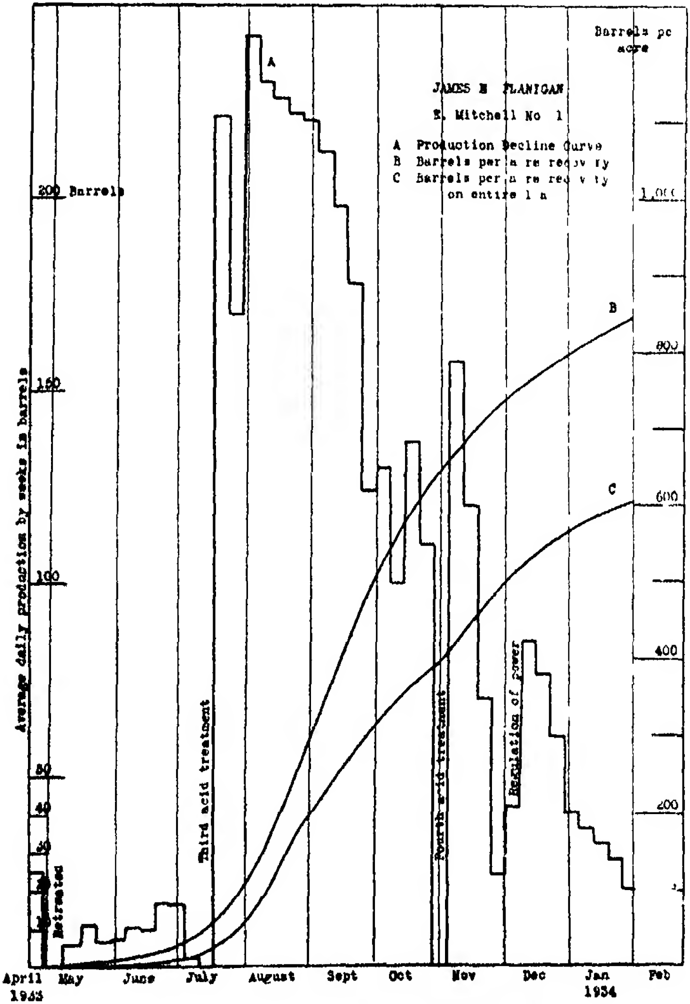


FIG 28 Production curves of Hart Wells

out to remove insoluble residues They are put to pumping soon afterward Whenever possible wells are pumped from central powers to reduce lifting costs

When the field was opened the wells were produced nearly to capacity with little back pressure The oil from the Hart Field contains a large percentage of gasoline, but little kerosene, and a large percentage of heavy oils The reduction in pressure at the well permitted escape of the volatile constituents and caused precipitation of paraffin in tubing and casing It is now necessary to remove this paraffin periodically by mechanical or chemical means and at considerable expense Reduction in pressures at the wellheads also caused encroachment of edge water All wells now produce some water In most cases this water may be drained off, but in some cases the oil must be steamed or treated with chemicals Lifting costs vary from 20 to 35 cents per barrel, with an average close to 30 cents per barrel The Napth-Sol Refining Company and the Old Dutch Refining Company, both of Muskegon, purchase the oil

ESTIMATES OF TOTAL PRODUCTION

Map 43 shows the probable producing area of the Hart Oil Field There is evidently only a small area of thirty-five or forty acres surrounding the original well The larger area to the west may approximate two hundred and fifty acres

The variable nature of the reservoir rock in the Hart Oil Field would make it impossible to estimate recovery on the basis of volume content Production records from Upper Traverse wells in the Muskegon Oil Field indicate an average yield close to 1,000 barrels per acre Figure 28, Curve *B*, shows the barrels per acre recovery from the Flanigan Mitchell No 1 Curve *C* on the same figure shows the barrels per acre recovery from the entire Mitchell lease — five wells on fifty acres These and other production records, which are now available on the Hart Oil Field, would not tend to increase recovery estimates beyond 1,000 barrels per acre The total production of the Hart Oil Field will probably not exceed 300,000 barrels To February 1, 1934, the field had produced approximately 52,000 barrels of oil or an average of 400 barrels per acre from the 176 acres drilled and producing

State Department of Conservation
Muskegon, Michigan

NICOLAS LENGLET DU FRESNOY IN THE LOW COUNTRIES, 1721

AN INEDITED DOCUMENT FROM THE ARCHIVES DES AFFAIRES ÉTRANGÈRES

MANSON MILNER BRIEN

THE Abbé Nicolas Lenglet du Fresnoy's trip through the Low Countries in the fall of 1721 has remained an hiatus in the records of his adventurous existence. His first biographers practically overlooked the event, and in succeeding years very little pertinent information has been disclosed. Recent discovery by the present writer in the French Archives des Affaires Étrangères of three inedited *Mémoires*, in Lenglet's own handwriting, promises to throw more light on the matter. Hence this article has as its *raison d'être* a review of the early material, and by the presentation of new documentary evidence, a definite account of the journey.

J. B. Michault, who first examined thoroughly Lenglet's career, neglected that Abbé's varied experiences in Flanders, particularly those of 1721. The biographer was content with these vague words: "Toujours actif et laborieux, l'Abbé Lenglet avoit sçu employer son tems pendant le séjour qu'il fit en Hollande et en Allemagne."[1] Michault's statement plainly discloses that he knew nothing tangible about Lenglet's travels. Indeed, the few lines were intended only as a prelude to a discussion of his stay in Vienna, and offered no facts about the purpose, time, route, or extent of his excursion.

It was not until 1829 that more precise knowledge was forthcoming. Then Delort in editing several documents relative to Lenglet's imprisonments devoted the following transition paragraph to his tour: "Dans une lettre autographe, datée de Septembre 1721, qui m'a été confiée, et qui se rattache à mon sujet, on voit qu'il [Lenglet] prit la résolution de partir par la route de Lille, Bruxelles et Cologne,

[1] Michault, J. B., *Mémoires pour servir à l'histoire de la vie et des ouvrages de Monsieur l'abbé Lenglet du Fresnoy* (Paris and London, 1761), p. 35.

pour se rendre à Vienne en Autriche, et y implorer la protection du vertueux empereur Charles VI, et le supplier, par la médiation du Prince Eugène de Savoie, chef de ses conseils, de prendre les mesures convenables *pour mettre pareillement à couvert la personne de Sa Majesté sur laquelle de justes alarmes avoient redoublé,* [2] auquel voyage il depensa la somme de huit mille livres, que ledit Abbé avait amassées par ses épargnes." [3]

Unfortunately Delort did not print the whole letter, which is now apparently lost. It would have been of inestimable value in checking Lenglet's divergent statements, especially in political affairs. As it is, we are obliged to accept this account of his trip upon Delort's authority which, save in two instances, is in substantial agreement with the *Memoires* written by Lenglet himself.

They were occasioned by Lenglet's arrest at Strasbourg upon his return from Vienna. Since he was suspected by Cardinal Dubois of being a party to an intrigue, the lieutenants of Count du Bourg, commander at Strasbourg, took Lenglet into custody on May 13, 1722. The Abbé was immediately placed in solitary confinement and questioned minutely upon his business in Austria.[4] The situation remained unchanged for almost two months.

Finally the impatient Cardinal drew up a list of twenty-one questions which he desired answered, and forwarded it to Du Bourg. On the sixteenth of July the latter held a two-hour conference with Abbé Lenglet, about which the Count reported: "Je lui ai fait prendre par écrit et lui ai dicté les articles du mémoire qui accompagnait la lettre de V. Em. Il travaille actuellement à y répondre amplement; dès que cet ouvrage sera en état, j'aurai l'honneur de vous l'adresser." [5] Such was the origin of these hitherto unexamined documents that yield much enlightenment on several obscure periods in his life.

Lenglet must have applied himself diligently, for his detailed answers required over seventy pages of manuscript, completely fin-

[2] The italics are Delort's and presumably represent a quotation from Lenglet's letter.

[3] Delort, Joseph, *Histoire de la détention des philosophes* (Paris, 1829), 2: 72.

[4] For a more detailed account of this arrest see Brien, Manson Milner, "Lenglet du Fresnoy: a Biography," *Pap. Mich. Acad. Sci., Arts and Letters,* 18 (1932): 463–465. 1933.

[5] Ravaisson, François, *Archives de la Bastille, documents inédits* (Paris, 1881), 12: 99. Count du Bourg to Cardinal Dubois, July 16, 1722.

ished by July twentieth. In reply to the twenty-one queries he composed three articles,[6] two of which were necessitated by the twelfth question: "Faire un Etat auguste de tout ce qu'il a entendu dire ou remarqué a Vienne et dans les autres lieux ou il a passé, sur les affaires de l'Etat, de l'Eglise et ce qu'il a remarqué des Differens Caractères de ceux qu'il a eu occasion de voir." [7] Count du Bourg, as good as his word, returned the documents to the Cardinal. He may have studied them, and having abstracted what interested him he confided the remainder to the Archives. Aside from a few references in the "Questions" to the commencement of his journey, it is the "first memoir" which narrates wholly the events of his sojourn in the Low Countries.

The handwriting of this *Premier Mémoire* is moderately large, bold, and flowing. The linked words and the graceful oversized capitals immediately attract the eye. (See Pl. XCV.) Particularly noticeable are the long tails on *f* and *p* and the old-fashioned *s*. Lenglet completed the letters *g*, *j*, and *y* by an elongated, unclosed loop upward to the left, but the loops on *z* turn to the right and are frequently closed. *Q* is the only letter which he habitually brought to an abrupt end by a straight line. The capital *C*'s are big and generally extend below the line. Lenglet always employed the small script delta with the upper loop to the left, and an elongated upper loop to the right on the capital *E*. At the conclusion of a word *s* was usually in a modern schoolboy's style, in most cases slightly larger than the preceding letters, and often the size of a capital. As a rule, his numerals were carefully formed. When he used them to emphasize a paragraph, a page, or an article, he unfailingly placed a small zero above them on the right. It can truthfully be said that Lenglet's pages are both pleasing and legible.

Beside Du Bourg's statement that Lenglet himself was actually engaged upon these *Mémoires*, the handwriting of the manuscript provides an indubitable witness that it comes from the Abbé's personal pen. These pages and an analysis of Lenglet's writing, made in 1751 by two government experts at the request of Police

[6] They are entitled: I. *Questions faites à l'abbé Lenglet du Fresnoy avec ses réponses, du 20e Juillet 1722.* II. *Premier memoire dont il est parlé cy dessus nº 12º.* III. *Second memoire dont il est parlé cy dessus nº 12º.* All are found in the Archives des Affaires Étrangères, Correspondance politique, Autriche 140: 305–340. (Hereafter cited as A. A. E., followed by page number.)

[7] A. A. E., p. 328v.

Lieutenant d'Hémery,[8] possess several traits in common. In both we note Lenglet's practice of linking his words together. There are the same long, oversized c's, and the same large final s's. The small zeros, likewise, were habitually found after the numerals. Without question, Abbé Lenglet composed and wrote in his own hand these three *Mémoires*.

Little did Lenglet dream, as he contemplated a journey to Vienna by way of the Low Countries, that he would be obliged to give an official account of his travels. Consequently he may have acted and written with a freedom not evident in a report composed when his liberty was at stake. He informed Dubois that the trip to Vienna was undertaken "uniquement pour obtenir de M. le Prince Eugene de Savoye un des canonicats vacants en Regale dans l'Eglise de Tournay."[9] Since 1710, when he had failed to secure a benefice, Lenglet had never ceased to envisage the possibility of future success. This became more of a reality in 1719, when the Abbé de Chaume, a canon of Lille, and many other friends at Tournai urged him to seek again the nomination.[10]

Lenglet's domestic situation at this moment undoubtedly made the canonship appear all the more inviting. At loose ends after his work during the Cellamare conspiracy,[11] he lived at his sister's home, occupied by literary trifles and the attempt to procure some sort of pension or benefice which would assure his personal independence.

In 1720 he discussed the wisdom of this trip with Monsieur Dufay, a former captain of the Guards, who had become attached to the household of Cardinal de Rohan. Dufay, though, dissuaded the Abbé from taking any action.[12] About the same time Lenglet also confided his hopes to Madame de la Barre, his sister. Unable to bear a separation, she broke down in tears.[13] Thus Abbé Lenglet was persuaded to remain in Paris during 1720 and six months of 1721.

As the summer drew to a close matters were apparently reaching the breaking point. Lenglet himself described the trouble. "Mais sur la fin de 1721, il vit qu'il ne pouvoit rien obtenir, pas même un

[8] Delort, *op. cit.*, 2: 94–98. Lenglet was the suspected author of an anonymous letter. To confirm this idea his writing was compared in detail with the incriminating document.

[9] A. A. E., p. 305r. The *Regale* was the right of a king or a titulary head to nominate the successor to a vacant benefice.

[10] *Ibid.*, p. 305r & v.

[11] Brien, *op. cit.*, pp. 462–463.

[12] A. A. E., p. 305v.

[13] *Ibid.*, p. 306r.

des canonicats de Soissons qui ne valont que 700 ou 800[lv] et d'ailleurs, il se trouvoit à la charge de son beau frère, chez qui il fut réduit à la dure extremité de vivre de pain et d'eau pendant plus de trois mois "[14]

Yet Lenglet's plight was not so terrible as it would first seem Monsieur de la Barre was not inhuman He had retired to his country place for the summer and wished to take Lenglet with him But the Abbé refused He was engaged in some historical and political research for Monsieur Leblanc,[15] and he had no desire to quit Paris The thrifty brother-in-law, however, refused to maintain two residences, so Lenglet, free to occupy the town house, had to shift for himself in the matter of food Angered at what he considered unjust treatment, the Abbé resolved to be no longer dependent upon his family He determined to seek the canonship at Tournai without delay[16]

It would seem that his decision was made very suddenly Lenglet hastily prepared to depart with great secrecy Even when ready to set out he did not mention his proposed journey to anyone, least of all to those who had dissuaded him in 1720 Nor did he bother to procure a passport He left Paris armed only with a permit from the Marquis de Torcy, the minister, to be supplied with post horses to Lille There he obtained a ticket for post horses to Menin At no instant was he required to produce any permission to leave the kingdom[17] And now we may continue the story as Lenglet wrote it for Cardinal Dubois

Premier Memoire[18]
dont il est parlé cy dessus n° 12°

Je partis de Paris vers La mi-Septembre 1721 Je restai quinze Jours a Lille, où j'achetai quelques livres chez Le S[r] Daniel Libraire, principalement pour M Le Blanc,[19] savoir un 13[e] volume des œuvres d'Aldrovandus,[20] dont j'ai eu pour ce ministre les 12 premiers vo-

[14] *Ibid*

[15] Leblanc, Claude (1669–1728), became Minister of War in 1718 When the Regent died, Leblanc was accused of diverting military funds He was tried and acquitted and resumed his old post in 1726

[16] A A E, p 306r and v

[17] *Ibid*, pp 306v, 307r

[18] The manuscript is reproduced exactly

[19] See note 15, above

[20] Ulysse Aldrovandi (1522–1607), an Italian doctor and naturalist, who received the chair of botany at Bologna in 1560

umes in folio reliés en Maroquin Rouge. J'ai acheté de plus pour M. Le Blanc quelques manuscrits, qui sont La Conference d'ardres[21] entre françois I. et Charles Quint, et un autre Livre de negociation, L'histoire de La Ville de Calais, et quelques autres, J'ai fait aller Le tout a Paris dans son temps, et Je devois les remettre dans la Bibliotheque de ce ministre à mon retour.[22]

Cette Ville à quelques Ecclesiastiques prés est fort tranquille Sur Les matieres de Religion.

Le pied Sur Lequel les especes sont actuellement en france fait un si grand bien à cette ville et à toute La frontiere, que Les commerçans Seroient tres fachez qu'on en diminuat la valeur, parce que cela empecheroit les Sujets des Paysbas autrichiens d'y venir faire les gros achats, qu'ils y font continuellement, à cause du prix de l'argent. Et il y avoit alors plus de 50 Carosses ou Berlines de Commande dans cette ville pour Bruxelles, Malines, Anvers, Gand et Bruges.

Au commencement d'octobre j'arrivai à bruxelles, où je restai environ 15 jours. J'y vendis 700 florins de change des medailles, que j'avois, et Le dit argent m'a Servi dans mon voyage, n'ayant aucun autre fond en partant de Paris,[23] que ces medailles, et une petite Caisse de Livres des Editions d'alde, Colines et gryphe[24] tous Reliez en maroquin, que j'ai vendus 300 florins de Change au S^r^ antoine Claudinot Libraire Sur La Cantersteen a Bruxelles.

Comme ce fut M. Le Prince de Rubempré,[25] qui fit acheter mes medailles par un françois, qui est Intendant de M. Le Prince d'Isenghien,[26] j'eus l'honneur de le Saluer, et je remarquai dans ce Seigneur un tres grand mecontentement du gouvernement present des Paysbas autrichiens, et Etant dans sa Bibliotheque, il ne fit pas difficulté de retourner Le portrait de Philippe V[27] et de me dire que c'etoit toujours là leur maitre. Ils aimeroient beaucoup mieux etre à

[21] Better known as the "Field of the Cloth of Gold," where Francis I and Henry VIII held their famous interview. Lenglet's error is glaring, but it might possibly be excused because of the existing conditions. According to Count du Bourg, he was slowly starving after his attempted escape had failed. See Ravaisson, *op. cit.* 12. 99. Count du Bourg to Cardinal Dubois, July 6, 1722.

[22] Part of Lenglet's work was to perfect Leblanc's excellent library.

[23] Compare with Delort's statement above.

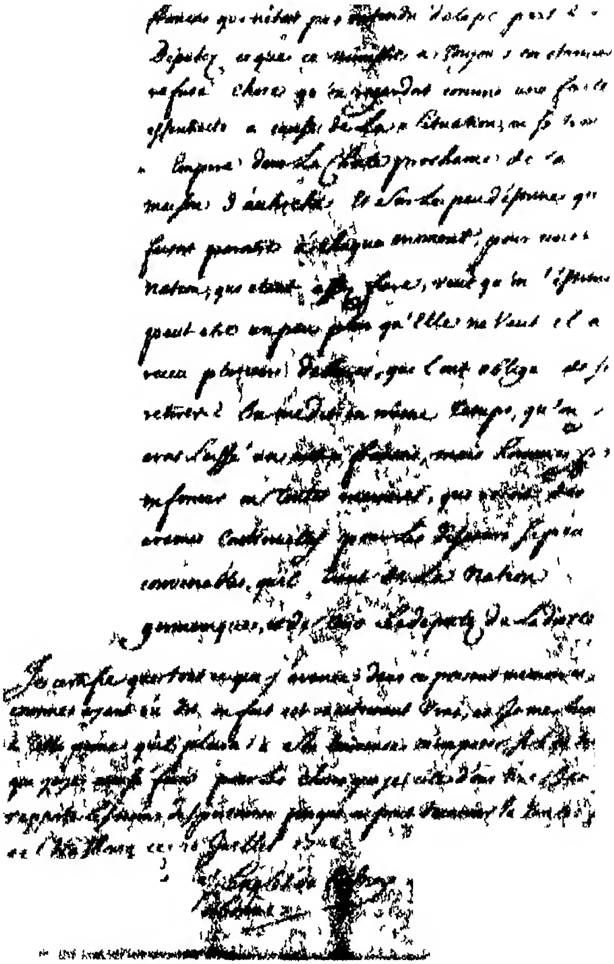
[24] Aldo Manuzio, the Elder (1450-1515), the founder of a great family of printers, whose editions are called "Aldines." He was the first to make use of italics. Simon de Colines (1480-1546), an early French printer. He married the widow of the famous Henri Estienne. Sebastien Gryphe (1491-1556), a printer at Lyons who gained renown because of his Hebrew, Greek, and Latin texts. He was the first to print the *Gargantua* and *Pantagruel* of Rabelais.

[25] Philippe-François de Merode, Comte de Montfort, who married the only daughter of the last prince de Rubempré and assumed the latter's titles and arms.

[26] Louis de Gandvillain, Prince d'Isenghien (1678-1767), a son of the famous French marshal of the same title.

[27] Philippe V (1683-1746), king of Spain and grandson of Louis XIV.

PLATE XCV



The last page of Abbé Lenglet's *Premier Mémoire*

l'Espagne à la france ou à un Prince particulier, que de Se voir Sous Les allemans La raison de Leur mecontentement, qui est general, vient de trois causes
1° du Traité de Barriere,[28] qui Les ruine, parce qu'ils sont obligés de donner tous les ans plus 2400 mil leurs especes pour Les garnisons hollandoises Et ces troupes prejudicient fort à la Religion, par Les predicans, qu'elles entretiennent dans toutes les Villes où elles sont et perdent Leur commerce, faisant Venir du fond de La hollande tout ce qui devroit être acheté dans le Pays
2° des demandes Continuelles qu'on Leur fait d'argent, sans qu'on leur montre l'employ des deniers deja [29]

(3°) françois qui n'etoit pas entendu de la pluspart des Deputez ce que ce ministre a toujours constamment refusé chose qu'on regardoit comme une faute essentielle à cause de La Situation, où se trouve L'Empire dans La Chute prochaine de la maison d'autriche Et Sur Le peu d'estime qu'il faisoit paroitre à chaque moment, pour une nation, qui etant assez fiere, veut qu'on l'estime peut être un peu plus qu'Elle ne Vaut, il a receu plusieurs deboires, qui l'ont obligé de se retirer On me dit en même temps, qu'on y avoit Laissé un autre francois, mais homme fort inferieur en toutes manieres, qui reçoit des avanies continuelles pour Les discours si peu convenables, qu'il tient de La Nation germanique, et de tous Les deputez de La diette [30]

Je certifie que tout ce que j'avance dans ce present memoire, comme ayant vû dit ou fait est exactement vrai et je me Soumets à telle peine qu'il plaira à Son Eminence m'imposer, si l'on trouve que j'aye accusé faux pour Les choses que je cite d'oui dire, Je rapporte Les noms des personnes par qui on peut decouvrir la Verité fait a Strasbourg ce 20 Juillet 1722

LENGLET DU FRESNOY Pretre Licentié de Sorbonne

Indeed Lenglet's *Mémoire* completely agrees with Delort in all save two details, the purpose and the funds Concerning the former it is quite possible that Lenglet may have had a crack-brained political scheme in mind He was not above such a maneuver, witness his almost single-handed effort three years before to influence the Duc de

[28] The name given to two treaties of 1709 and 1715, which granted the States General the right to guard several cities in the Spanish Low Countries against a possible French invasion

[29] The manuscript breaks at this point and two pages are apparently lost

[30] By his reference to the Diet we may presume that Lenglet continued on his journey by way of Cologne and Ratisbon, the permanent seat of that institution Both cities were directly on his route to Vienna He must have been in Ratisbon when the deputies gathered for the autumn session

Bourbon to seize the regency Lenglet's hurried, secret departure might imply a similar idea, which, of course, he would not reveal to the Cardinal, who strongly suspected an intrigue However, since the Abbé was prone to magnify his own importance and since he actually desired the Tournai benefice, it is only reasonable to conclude that after all the primary object of his journey was the award of a canonship

Likewise the discrepancy in regard to Lenglet's finances was not exceedingly great He was a dealer in rare books and valuable manuscripts On more than one occasion he invested his money in a volume which he sold at a profit Thus it seems probable that the *épargnes* mentioned by Delort referred to the editions and the medals disposed of in Brussels, for the shrewd Lenglet, who some months later realized upon other books, may have converted his assets into cash only when absolutely needed In any event, Abbé Lenglet was able to proceed through the Germanies to Vienna unembarrassed by further financial necessity

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THE *ACCADEMIA DEGLI UMORISTI* AND ITS FRENCH RELATIONSHIPS*

FRANCIS W. GRAVIT

PELLISSON, speaking of the origins of the French Academy, is reminded of an Italian body of somewhat similar nature, the *Accademia degli Umoristi*. One cannot read the letters of Balzac, Chapelain, Voiture, or Peiresc without encountering the name. Gabriel Naudé, Gassendi, and Tallemant des Réaux all make mention of it, and, as will be shown later, it appears in connection with other Frenchmen of the period. It has, however, been almost completely neglected in the annotations. Tamizey de Larroque passes it by completely in his editions of the letters of Chapelain, Peiresc, and Naudé. Ubicini,[1] editing the works of Voiture, refers merely to Pellisson. Uri, who treats these men somewhat in his work on François Guyet, apparently has never heard of it and merely mentions the academy of the *Crusca*, as the general type of all the rest.[2] Of the Italians Tiraboschi presents certain good information,[3] but this is by no means complete. The most recent discussion, by Michele Maylender, in his *Storia delle accademie d'Italia*,[4] brings to light some new materials, but, being encyclopedic by nature, is of necessity somewhat brief in treatment and does not do justice, any more than its predecessors, to the French ramifications of the body. In view of these facts a somewhat extended note would seem useful. The aim of this paper is, therefore, to describe the Academy itself, and to focus attention upon its relations in France.

Pellisson[5] speaks of the *Umoristi* as follows: "Ceux qui ont parlé

* After their first occurrence titles are given without bibliographical data and some are cited in condensed form.

[1] *Œuvres de Voiture*, éd. M. A. Ubicini (Paris, 1855), II, 98.

[2] Uri, Isaac, *Un Cercle savant au XVII^e siècle: François Guyet* (Paris, 1886), p. 12.

[3] Tiraboschi, G., *La storia della letteratura italiana* (Milano, 1822–26), VIII, Part I, 65–69.

[4] (Bologna, 1930), V, 370–381.

[5] Pellisson, Paul, et Olivet, Abbé Pierre-Joseph Thoulier d', *Histoire de l'Académie française*, éd. Ch. Livet (Paris, 1858), I, 7–8.

de l'Académie des Humoristes de Rome, disent qu'elle naquit fortuitement aux noces de Lorenzo Mancini, gentilhomme romain, que plusieurs personnes de condition d'entre les conviés, pour donner quelque divertissement aux dames, et parce que c'étoit au carnaval, se mirent à réciter premièrement sur-le-champ, et puis avec plus de préméditation, des sonnets, des comédies, des discours, ce qui leur fit donner le nom de *Belli Humori*, qu'enfin, ayant pris goût insensiblement à ces exercices, ils résolurent de former une Académie de belles-lettres, qu'alors ils changèrent le nom de *Belli Humori* en celui d'*Humoristi* et choisirent pour devise une nuée qui, après s'être formée des amères exhalaisons de la mer, retombe en pluie douce et menue, avec ces trois mots du poète Lucrece pour âme, *Redit agmine dulci* "

Tiraboschi [6] concurs with the points stated above, except that he makes the founder of the body *Paolo* Mancini, as does also Maylender [7] Tamizey de Larroque was led into the error of stating apropos of Dom Angelo Grillo, of whom more later, that he founded the *Umoristi* [8] There is no evidence pointing to the truth of this statement We learn further from Tiraboschi [9] that the real guiding spirit of the body was one Gaspero Salviani, a friend of Mancini The origin of the group is generally dated 1603, and it continued to meet every fortnight until 1670, although this routine was more and more apathetically followed toward the end of the period [10]

The membership was large and contained the names of the most prominent men in seventeenth-century Rome, among others, Pope Urban VIII (Maffeo Barberini), and at one time as many as sixteen cardinals,[11] among them that famous patron of letters Francesco Barberini, the pope's nephew Barberini's secretary, the scholar Girolamo Aleandro, was also of the group, as were many literary men, the best known of whom are Alessandro Tassoni, Giovan-Battista Marino, the poet who, during his eight years' residence in Paris, had a very considerable share in the extreme preciosity of

[6] *Op cit*, VIII, Part I 66 [7] *Op cit*, V 372

[8] Tamizey de Larroque, Philippe, "Lettres inédites de Gabriel Naudé à Peiresc" *Bulletin du bibliophile* (1886), p 125, note 3

[9] *Op cit*, VIII, Part I 66

[10] Maylender Michele, *Storia delle accademie d'Italia* (Bologna 1930) V 370-371

[11] *Lettres inédites de Gabriel Naudé* , p 125

the Hôtel de Rambouillet,[12] Agostino Mascardi, and Giovan-Battista Guarini, the famous author of the *Pastor Fido*.[13] Among non-French foreign members are to be noticed particularly Lucas Holstenius (Luk Holste) of Hamburg, librarian of Cardinal Barberini and classical scholar, and Leo Allatius, or Allazzi, a Greek who early came to Rome, where he finally was made Vatican librarian. Maylender[14] quotes the larger part of a document, signed by some 620 names, drawn up in 1608, at which time the members solemnly pledged themselves to observe all the rules and regulations of the Academy. This represents an indication of the total membership throughout the life of the body, rather than the membership at any *one* date, since it is obvious that the names of Guarini, who died in 1612, and Gabriel Naudé, who did not arrive in Rome until 1631,[15] could not have been affixed simultaneously. That this group was always popular and had in its prime a very large membership is, however, evident from the fact that in 1614, because of the crowded condition of the roster, it split off into another body, the *Accademia dei Malinconici*.[16] The *Umoristi* had previously, in 1608, also given birth to the *Ordinati*, as a result of internal disagreements at that time.[17]

Such laws and regulations as have come down to us are meager. They are reported in the works of Gian Vittorio Rossi, himself a member, who wrote under the name of Janus Nicius Erythraeus. They are interesting, particularly the statement that "women of good family, surpassing in beauty and age,' together with their husbands should have the privilege of attending the sessions — a provision which seems to reflect the social origin of the body. Apparently, however, no women were allowed as regular members, despite their share in its original formation, since no women's names are to be found in the list referred to above. Some members, especially charter members, were exempt from taking part in the exercises if they so desired, and the public meetings were to be

[12] Lanson, G., *Histoire de la littérature française* (Paris, 1924), p. 381.

[13] Naudé, Gabriel, *Jugement de tout ce qui a esté escrit contre le Cardinal Mazarin, ou Mascurat* (Paris, 1650), pp. 143–147. In the following notes this title is abbreviated as *Mascurat*.

[14] *Op. cit.*, V, 375–381.

[15] Gassendi, Pierre, *Viri illustris Nicolai Claudij Fabricij de Peiresc vita* (The Hague, 1655), p. 153.

[16] Maylender, *op. cit.*, V, 374. [17] *Ibid.*

conducted by an elected officer the *principe* – one of whose duties was to see "that the walls were magnificently decorated" Although no one was admitted if he received one black ball, it is apparent from the size of the group that this privilege was not greatly exercised[18] According to Gassendi,[19] public funeral honors were paid by the Academy to its *principi,* and he adds that in forty years only six such ceremonies had been performed Still another curious regulation reported by Erythraeus is that forbidding the quotation of any living author during an official session Once when a young man had cited a fiery Tuscan poetess and had been rebuked by the censor, the lady, a certain Margarita Sarrochia, was so enraged that she made a violent public scene, and finally prevailed upon the young man not to attend any further sessions of the Academy[20]

In addition to the *principe,* the body had among its officers a *censore,* "a cui toccava l'essaminare i componimenti che doveano publicarsi"[21] There were also a *segretario, a tesoriere,* a *primo consigliere* and a *secondo consigliere* The duties of the last two are not clear, but it is probable that they were the same as those of similar officers in the academy of the *Oziosi* at Naples, of which J-J Bouchard reports that there were four counselors to settle quarrels amongst the members[22] In the agreement of 1608 mentioned above we find inscribed twenty-four *principi* and two *censori* The other titles appear only once, at the beginning There is no way of telling how nearly complete the list is, but it gives a rough idea of the number of elected presidents the society had in its seventy years of existence, an average of about one every three years The *principe* presided over the biweekly meetings in a magnificent hall located, according to Naudé,[23] in the palace of the founder, Paolo Mancini This hall was decorated in part at least with the mottoes and pic-

[18] See Erythraeus, *Eudemia* (Leyden 1637), III 48–49

[19] *Op cit*, p 252

[20] Erythraeus, *Pinacotheca imaginum illustrium virorum* (Leipzig, 1692), p 261

[21] Tiraboschi, *op cit* VIII, Part I 67

[22] Marcheix, Lucien, *Un Parisien à Rome et à Naples en 1632 D'après un manuscrit inédit de J-J Bouchard* (Paris, 1897), p 27

[23] *Mascurat,* p 153 Naudé's statement is borne out by the following title quoted by him in another connection (p 128) Totti, Pamphilio, *Ritratto di Roma* (Roma, 1638) "Nella strada poi del corso alla man diritta, vi è la nobile habitatione dei Signori Mancini, dove si fa la famosissima Accademia dei Signori Humoristi spesse volte con presenza d'Eminentissimi Cardinali"

tures of the more illustrious members[24] At the back was a circular gallery in which sat the guests during the public sessions — from which ' le dame e le principesse romane godevano anch' esse di starsi spettatrici di sì lieto spettacolo "[25] This statement, taken in connection with the by-law quoted above, would make us believe that women were particularly welcomed as onlookers at these meetings, doubtless adding a note of gayety and charm to the distinguished gathering of *letterati* and scholars On special occasions such as the funeral services of Peiresc the hall was so filled that it could hardly hold the spectators[26] Naudé[27] says of these meetings, "ces assemblés se font à iour nommé et intimé par le Bedeau à tous les Academistes en des salles de respect, le [*sic*] mieux parées et ornees qu il est possible, en presence des Cardinaux Gouverneurs de Ville et de Provinces, Seigneurs de marque, principaux Officiers, avec une foule d'Auditeurs semblable à celles que tu vois bien souvent aux Declamations publiques des Colleges ou au Barreau quand on y doit plaider quelque cause extraordinaire, Enfin il faut croire que les Academistes qui sont ordinairement personnes de credit et de merite, ne manquent pas aussi de faire eclater ces actions le mieux qu il leur est possible, parce qu'elles servent d'Epoques assez remarquables à tout le reste de leurs vies "

As to the sessions themselves, information is somewhat meager We do know, however, that there was at each meeting an "orazione, o un poema o altro componimento" which had been assigned or arranged for in advance Then followed other members ' recitando le lor poesie "[28] These poetical exercises were a considerable part of the proceedings, apparently, for Gabriel Naudé asserts that, at the obsequies for Angelo Grillo, Benedictine scholar, abbot of Saint Paul's in Rome, and *principe* of the Academy, who died in 1632, "beaucoup d'académistes récitèrent plusieurs poésies "[29] They were not the only type of composition, however, for there is record that

[24] Erythraeus, *Pinacotheca*, p 96, speaking of Guarini 'Nam et in parentis eum loco dilexit, ejusque adhuc superstitio imaginem, magna in tabula, summi artificis manu depictam et corona aurea in loco Academiae posuit '

[25] Tiraboschi, *op cit*, VIII, Part I 69

[26] Gassendi, *op cit*, p 252 See also Tamizey de Larroque, *op cit* p 125, where we are told that at the funeral of Angelo Grillo there were "tant d autres personnes que la moitié fut contrainte de demeurer dehors '

[27] *Mascurat*, pp 149–150

[28] Tiraboschi, *op cit*, VIII, Part I 67

[29] *Lettres inédites de Gabriel Naudé*, p 125

the members were invited to make known publicly their learned works[30] Gassendi bears out this statement He says that the Academy "is a reknowned Society of learned men, who meet twice every moneth, where in full Academy, one of the Academicks makes an Oration, others recite their Poems and other works worthy of a learned auditory "[31] Chapelain also gives evidence of the importance of public recital, for he speaks of the Academy as "un auditoire célèbre où l'on fait principalement profession de l'éloquence "[32] Aleandro once gave a series of three very dull lectures explaining in detail the motto of the society[33] On another occasion David Flurance de Rivault, a visiting Frenchman, delivered a discourse on *Minerva armata, sive de conjungendis letteris et armis*[34]

According to Tallemant des Réaux, one of the set discussions was the question whether "la langue Française estoit parvenue à un aussi haut point que l'Italienne," which would be extremely interesting if the statement were entirely credible He states that this discussion aroused such feeling in Jean-Jacques Bouchard, one of the French members, that he offered to translate the *Congiura del Fiesco* of Mascardi to prove the superiority of French[35] Unfortunately Bouchard himself disproves this statement in a letter to Peiresc in which he says that he has kept his work a secret from all his friends in Rome, and begs him not to mention it in his letters[36] It is not at all unlikely, however, that questions of this nature were at times discussed in that cosmopolitan society of authors and scholars, in a period when the position of the French language was being definitely fixed Bouchard at length sent his work to Richelieu and to Chapelain, and apparently failed to impress them with his effort Chapelain says, "Je luy fais peut estre tort, mais j'avoue que j'appréhende pour sa réputation qu'il l'envoye à son Éminence "[37]

[30] Tiraboschi, *op cit*, VIII, Part, I 67

[31] *The Mirrour of True Nobility and Gentility, being the Life of Nicolaus Claudius Fabricius*, Wm Rand, trans (London, 1657), Part II 233

[32] *Lettres de Jean Chapelain*, éd Tamizey de Larroque (Paris, Imp Nat 1880–83), I 307, à Godeau, 18 octobre, 1638

[33] Maylender, *op cit*, V 373

[34] Rome, 1610, 8º Cf Michaud, J M, *Biographie universelle*, article "Rivault"

[35] *Historiettes* (Paris, 1852), V 483

[36] Tamizey de Larroque, "Lettres inédites de J-J Bouchard," *Le Cabinet historique* (1881), Part I 144

[37] *Lettres de Jean Chapelain*, I 299, à Balsac, 2 octobre, 1638.

Although Latin occasionally had its place in this group, the vernacular was the customary language employed. Voiture thinks a letter accepting the membership voted to him must be in Latin.[38] Bouchard gave the funeral eulogy of his friend Peiresc in Latin.[39] Rivault spoke in Latin. Yet Naudé[40] asserts that "Bruny, secrétaire du Cardinal d'Este et assés bon poéte, fit l'Oraison funèbre [de Grillo] en vulgaire . . . ," as was likewise that of Aleandro,[41] whose speeches on the *Impresa* of the Academy were also in Italian. It is only natural that a group growing up spontaneously, as this one did, and counting on a large audience of non-members, among whom were many women, should have employed the vulgar idiom under ordinary circumstances. Voiture is replying to a formal invitation, which was probably also couched in Latin, and consequently feels the need of a very formal missive. Rivault was a Frenchman and may well have used Latin because of a distrust of his command of Italian. Although Bouchard knew Italian very well,[42] he was always a *poseur* and probably put his oration for Peiresc into Latin to impress the august gathering with his ability.

The funerals were probably the most imposing of the exercises. That of Marino, who had been elected president when he returned from France in 1623, the author of the affected poem *Adone*, was celebrated some two weeks after his death in 1625.[43] They did not always follow immediately upon the death of the person honored, however. Aleandro died in 1629, and it was only in December, 1631, that his patron Francesco Barberini caused funeral services for him to be held at his expense. "Nous avons ici celebré les funerailles de feu s^r^ Hierosme Aleandro en l'Academie des Humoristes le 21 Decembre passé auxquelles assisterent cinq Card^aux^ Academiciens et six autres, et grand concours de beaux esprits, qui reciterent quantité de vers en son honneur. La sale fut parée de deuil, et de peintures de la main du s^r^ Pietro Cortonese tres excellentes *in chiaro oscuro* qui reprentoient les quatre sciences qu'il avoit professées, la Theologie, la Jurisprudence, l'Histoire, et la poesie avec parures et

[38] *Œuvres de Voiture*, éd. Ubicini, II. 98.

[39] It is reproduced by Gassendi, *op. cit.*, pp. 257–275 (see note 15).

[40] *Lettres inédites de Gabriel Naudé . . .*, p. 125.

[41] *Orazione nella morte di J. Aleandro detta in Roma nell'Accademia degli Umoristi ai 21 di Decembre, 1631, per Gaspero de Simeonibus.* In Parigi per Sebastiano Cramoisy, 1636, 4°.

[42] *Lettres de Jean Chapelain*, I. 299.

[43] Belloni, Antonio, *Il seicento* (Milano, n.d.), p. 71.

ornements et marques extraordinaires Je travaillai aux Inscriptions car MS le Card[al] mon maistre, qui nous fournit l'argent pour la despence, avoit agréé qu'avec MS Holstenius i'en eusse le soin, mais le tout s'imprimera "[44] In January the funeral of Grillo was also very brilliant, performed in the presence of his portrait surmounted by a gold crown,[45] before numerous cardinals and other persons of quality, and was paid for by the Benedictines [46] The most famous of these eulogies was that of Nicolas Fabri de Peiresc, *conseiller au parlement d'Aix* and correspondent of all the famous scholars of his day It marks apparently the only occasion when such honors were paid to one not a president It was given on December 27, 1637, in the presence of ten cardinals, including his particular friends Francesco Barberini and Bentivoglio These eminent prelates sat in a room draped in black and dominated by a picture of Peiresc From the somberly dressed rostrum the orations were given "The most choyse wits in all the City, recited Verses in prayse of the deceased, in Italian, Latin, and Greek, and his funeral Oration neat and eloquent was pronounced by Joannes Jacobus Buccardus, who was chosen to perform that Office, both for the excellency of his witt, the great love he bore his Countrey, and his special affection to the memory of the party deceased," according to Gassendi's biography of Peiresc [47] The oration, says Chapelain, to whom Bouchard sent it, was laudable for its Latinity and its careful development, but in his opinion lacked the fire and vigor necessary to the spoken address, in fact, seemed, "plustost dictée par un historien ou relateur que prononcée par un orateur " [48]

After paying their respects to Peiresc in this manner, the *Umoristi* united in the publication of a *Panglossia*, containing eulogies of Peiresc in forty languages, including, says Tamizey de Larroque,[49] Hebrew, Syriac, Persian, Georgian, Armenian, Ethiopian, Coptic, Slavic, Russian, Polish, Albanian, even Japanese and Peruvian, not to mention the better-known languages of Europe [50] This collection of mortuary respects had great fame in France at the time of its

[44] Bibliothèque Nationale, Collection Dupuy, MS 9530, ff 294v–295 Lettre de J-M Suarès à Peiresc Rome, 22 janvier, 1632

[45] Erythraeus *Pinacotheca* , p 238

[46] *Lettres inédites de Gabriel Naudé* , p 125

[47] Part II 234 (see note 31)

[48] *Lettres de Jean Chapelain*, I 307, à Godeau, 8 octobre, 1638

[49] *Ibid* , p 359, note 1

[50] *Monumentum Romanum Nicolao Claudio Fabricio Perescio, senatori Aquensi,*

publication, partly because of the position of Peiresc among the scholars of the day, partly because Bouchard was never backward in displaying any product of his which might enhance his chances for either a bishopric or a seat in the *Académie française* Balzac is frankly skeptical of the work and comments to the effect that "Pour aller jusqu'à quarante [langues], il faut qu'il y en ait vingt-trois que Scaliger ignorait,"[61] and Chapelain raises his hands in horror at the thought, but is finally stirred by the receipt of the book to write a bad sonnet of his own on the death of Peiresc, thus making the honors even[52] Yet it is interesting to note that he wrote to Bouchard that Il ne s'est jamais rien imaginé de si superbe, ny de si royal pour les testes couronnées dans tous les siècles'[53] Gassendi,[54] of course, speaks with appropriate gratitude of this monument, which he viewed as a fitting crown to the glory of the excellent friend whose biography he was writing

It had not required the distribution of this work to spread abroad the fame of the *Académie des Humoristes*, as it was called in France Already in 1610 Flurance de Rivault (1571-1616), the last of the tutors of Louis XIII, and editor of several texts for the young prince's benefit, had taken a trip to Rome, where he was duly enrolled as a foreign member of the Academy, which he subsequently addressed in Latin, as we have mentioned above He was probably the earliest French member of the group Fired with enthusiasm from his experience, Rivault published soon after his return to Paris a plan for an academy in France and its introduction at court[55] Rivault, one of whose ideas was to have the young king harangued by the scholars of the day,[56] unfortunately died four years after his book was published, without having been able to impress his ideas permanently on the government

doctrinae virtutisque causa factum (Vatican Press, Rome 1638, 4°) This also contains the oration of Bouchard The *Panglossia* goes from page 85 to page 119

[61] *Œuvres*, éd Valentin Conrart (Paris, 1665), I 804, à Chapelain 20 novembre, 1639

[52] *Lettres de Jean Chapelain*, I 459, à Balzac, 20 juillet, 1639

[53] *Ibid*, p 444, 26 juin, 1639, note 5

[54] *Op cit*, p 253

[55] *Le Dessein d'une académie et l'introduction d'icelle en la cour* (P Le Court, Paris, 1612, 8°)

[56] Cf his *Discours sur le dessein de faire entretenir le roy par des hommes savans* (Vérac Paris 1610, 8°)

The French member best known in our day was Voiture, who went to Rome toward the end of 1638 and was there presented to the *Umoristi*. Some time later, apparently unknown to him, he was elected to membership.[57] In 1640 he writes wittily to his friend Costar, concerning the new honor:

> Il y a parmi eux [les Romains] une académie de certaines gens qui s'appellent *les Humoristes*, qui est à peu près, comme qui diroit Bizarres, et en effet ils le sont tant, qu'il leur a pris fantaisie de me recevoir dans leur corps, et de m'en faire donner avis par une lettre que m'a écrite un de leur compagnie. Il faut que je leur en fasse une autre en latin pour les remercier et voilà ce qui me met tant en peine. J'en suis pourtant dès le moment que vous m'êtes venu dans l'esprit, car il me semble que voilà votre vrai fait, et un homme qui est en Poitou et qui écrit des lettres latines de gaieté de cœur ne me sauroit pas refuser cela. Ils ont pour devise un Soleil qui tire des vapeurs de la mer qui retombent en pluie, avec ce mot de Lucrèce: *Redit agmine dulci*. Voyez, je vous supplie, si vous trouverez quelque chose à leur dire sur cela et sur l'honneur qu'ils m'ont fait et sur le peu que je vaux.[58]

Voiture was notably light-hearted in his attitude toward academies, and it is not to be wondered at too much that he delegated to a friend the task of thanking this "Roman Academy." Chapelain complains of his neglect of the *Académie française*: "Le nom académique de M^r^ Voiture est *il Negligente* ou, si vous voulés, *il Trascurato*. Jamais homme ne fut moins à l'Académie que luy, et la vostre des Humoristes se peut vanter de l'avoir plus veu en trois jours qu'il a esté à Rome que la nostre en quatre ans qu'il y a que nous l'y avons receu."[59] Costar obliged with a letter to be found in the *Entretiens de Voiture et de Costar* (Paris, 1654, 4°, p. 130).

Chapelain and Balzac, who several times mention the *Umoristi*, were never members, and speak of them primarily in relation to Jean-Jacques Bouchard and his *Panglossia*. Bouchard (1606–41), a *débauché* and a man of most unlovely character, went to Rome in 1630 as the result of the systematic debauching of a servant girl in his father's house — an affair he has somewhat too frankly described in a book called *Les Confessions et voyage en Italie de Jean-Jacques Bouchard* (Paris, 1881), of which the editor says that the other Jean-Jacques would have gasped in amazement had he been able to read it. In the letters to Balzac Chapelain continually complains of his greed,[60] yet he counsels tolerance because of the intellectual

[57] *Œuvres de Voiture*, éd. Ubicini, p. xii.
[58] *Ibid.*, pp. 98–99.
[59] *Lettres de Jean Chapelain*, I, 357, à Bouchard, 6 janvier, 1636.
[60] See *ibid.*, pp. 257, 299, 469, *et passim*.

qualities he finds in his Roman correspondent. Bouchard has left little trace of his avaricious life except his bad character and a Latin version of the Byzantine chronographer Theophanes, which he made at the request of Cardinal Barberini, who was his patron at Rome.[61]

The date of the election of Peiresc (1580–1637) to membership is unknown. He could not have been received while in Rome in 1600 since the Academy was not yet formed. His close friendship with many important persons in the group sufficiently explains his membership, however. Cardinal Barberini and Pope Urban VIII were always good friends, as were Aleandro, Cardinal Bentivoglio, del Pozzo, and others. He seems to have accepted the honor calmly, because all we know about his membership is that he apparently belonged in 1631, when he mentions the Academy to Bouchard, who had recently been admitted. This is the only reference to the body in the published part of his extensive correspondence.[62]

Gabriel Naudé (1600–53), who went to Rome in 1631 with Cardinal Bagni,[63] was soon made a member.[64] He is known to posterity chiefly for his *Avis pour dresser une bibliothèque* (Paris, 1644), one of the first theoretical treatises on libraries, published not long after his recall from Rome to take charge of Mazarin's library. Naudé has left a certain amount of information concerning the *Accademia degli Umoristi* in his *Jugement de tout ce qui a esté escrit contre le cardinal Mazarin, ou Mascurat* (Paris, 1650), to which we have already several times referred. It is an elaborate defense of his patron during the Fronde, in which he connects the name of Mazarin with that of Mancini, the founder of this "illustrious" academy, through the cardinal's nieces, one of whom, the famous Maria Mancini, was Louis XIV's first love.[65] It is interesting to note in this connection that Mazarin was also a member of the body.[66] Naudé, by his position and learning, was well known among scholars in Paris, particularly that large group which met about the brothers Dupuy in the

[61] Pelissier, L.-G., "Les Amis d'Holstenius," *École française de Rome, Mélanges archéologiques et historiques* (1887) p. 82.

[62] *Lettres de Peiresc*, éd. Tamizey de Larroque (Paris, 1888–98), IV. 69.

[63] Franklin, Alfred, *Histoire de la Bibliothèque Mazarine* (Paris, 1901), p. 7. *Lettres de Peiresc*, II. 273, à Pierre Dupuy, 23 mai, 1631.

[64] See list of members given by Maylender, *op. cit.*, V. 379.

[65] Silvagni, Umberto. *Il Cardinal Mazzarino* (Turin, 1928) p. 428.

[66] See list of members given by Maylender, *op. cit.*, V. 377.

library of François-Auguste de Thou,[67] who was executed in 1642, when implicated in the plot of Cinq-Mars against Richelieu

A somewhat less known member, who is occasionally remembered for his legal treatise *De l'usage des fiefs et autres droits seigneuriaux en Dauphiné* (Grenoble, 1664, 8), was Denis Salvaing de Boissieu (1600 83) A friend of Peiresc, he visited him before going to Italy in 1633, and of him Peiresc wrote to Bouchard "j'ay eu l honneur de voir icy M de Boissieu, gentilhomme des meilleurs maisons, et des mieux alliées du Daulphiné, qui est doué des plus dignes parties d erudition, de valleur et d'honesteté que puisse avoir aulcun autre de sa condition, dont je ne doubte pas que vous ne soyez bientost amoureux, et que vous ne me sçaichiez bon gré de l'occasion que je vous donne par cette adresse, et de le voir possible un peu plustost, et avec un peu plus de confiance que vous n'eussiez faict "[68] After a dissolute youth he accompanied the Duke of Créqui on a mission to Rome and was chosen to harangue the pope, which he did boldly and in a way not pleasing to the pontiff He refused, however, to suppress any of his speech, and it was subsequently printed (Rome et Paris, 1633) Boissieu must have been among that group of whom Bouchard wrote "Parmy touts ces curieux [la suite de Créqui], il y en a néantmoins quelque demi-douzaine de plus mitigés et qui ne se tenant pas enfermés tout au long du jour dans le cabaret et dans le bordel comme les autres, paroissent quelquefois dans la boutique *del Sole*, ou ils font fleurir les espées murs de Paris Videl et S Amant y président, et m'a-t-on dit qu'ils me veulent prendre pour leur assesseur, m'ayant déjà érigé en bel esprit a mon desceu Ce sera pour joindre à mes autres qualités d'Humorista et Otioso "[69] This tendency toward the intellectual life gained Boissieu a membership in the *Umoristi*[70] Upon his return to Paris he was made *conseiller d'état* by Richelieu, until he finally retired to a presidency in the *Chambre des comptes* of Dauphiné[71] There is no evidence that the poet Saint-Amant, who is mentioned here,[72] was ever a member,

[67] Uri, *op cit*, p 44 (see note 2)

[68] *Lettres de Peiresc*, IV 83

[69] Tamizey de Larroque, "Lettres inédites de J J Bouchard," *Le Cabinet historique* (1881) Part I 159–160

[70] *Mascurat*, p 146

[71] Michaud, J M, *Biographie universelle*, article "Boissieux"

[72] It was Marc Antoine Gérard, the poet, and not Jean-Tristan, the archaeologist, who was with the Créqui mission in 1633 See Schönherr, P, "Saint Amant, sein Leben und Werke," *Zeit f franz Spr und Lit*, 10 (1888) 120

although it is extremely possible in view of the circumstances leading to the election of Boissieu

Before closing this discussion we must mention three men who were also members, but who have left little trace of their connection with this body. We know they were members, because they wrote some of the eulogies in the *Panglossia*, and Bouchard distinctly says that this part of the *Monumentum* "appartient aux Academistes" [73] Of the nature of their connection we have little evidence. Scipion de Grammont (? 1638), the first of them, a numismatist and *amateur* now almost forgotten, was *secrétaire du cabinet* of Louis XIII. His best-known work was a treatise on the theory of money (*Le Denier royal, traité curieux de l'or et de l'argent*, Paris, 1620). He has also left some French and Latin verse and a curious work on a system for learning foreign languages, which particularly attacks Latin grammars written in verse [74] He was present at the obsequies for Peiresc,[75] and wrote some rather bad Latin verses concerning the occasion, celebrating the *Panglossia*. To him were also entrusted the French verses for the work, which were not of a quality to keep his memory alive [76] Another writer for the *Panglossia* was Honoré Bouche (1598 1671), the Provençal historian, friend of Gassendi,[77] and of Peiresc, who sent him to Rome at the end of 1634, loaded down with recommendations, particularly to Cardinal Barberini [78] Of him Peiresc wrote to Holstenius "Il est fort honneste et fort modeste, et bien qu'il soit en reputation de doctrine entre ceux du pais, de la profession de la Theologie scholastique, il ne s'en presume pourtant pas beaucoup, et n'en vault pas moings aussy. Il est fort de mes amys et de toute nostre mayson et si vous pouvez l'adsister et favoriser en quelque chose de pardelà auprès de l'em^me^ Card^al^ patron, ou des aultres de sa cour . . . je vous en auray particuliere obligation . . . " [79] With such commendations it is not surprising that Bouche was soon elected to the *Umoristi*. Bouche is the author of one of the best source works on seventeenth-century Provence [80]

[73] Tamizey de Larroque, "Lettres inédites de J.-J. Bouchard," *Le Cabinet historique* (1881), Part 1 165

[74] Cf. Michaud, J. M., *Biographie universelle*, article "Gramont"

[75] Bayle, Pierre, *Dictionnaire historique et critique* (Paris, 1820), XI 517

[76] Humbert, René, *Un Amateur: Peiresc* (Paris, 1933), p. 278

[77] *Lettres de Peiresc*, IV 123, note 2

[78] *Ibid.*, VI 705

[79] *Lettres de Peiresc*, V 430

[80] *La Chorographie ou description de Provence* (Aix, 1664)

A somewhat more important personage was Joseph Marie Suarès (1599–1677), a learned antiquary who also dallied with the poetic muse. He was for a time librarian to Cardinal Barberini and *cameriere* or officer of the chamber to Urban VIII. After 1633 he was Bishop of Vaison, and returned to France only to resign in 1666 and pass the rest of his life as Vatican librarian in Rome. Suarès was likewise a friend of Peiresc, with whom he was in correspondence.[81] He was present at the funeral exercises for Aleandro.[82] Suarès was charged with the redaction of the Latin verses for the *Panglossia*.

If the *Accademia degli Umoristi* is of primary importance only in the history of Italian literature and scholarship, it can yet be seen from the names already mentioned that it had its place also in France. It seems that the person most largely responsible for its French memberships was Peiresc. Bouchard, Boissieu, Bouche, all went to Rome recommended by him and soon were elected to the body. Naudé is highly praised in a letter to Holstenius[83] and promptly becomes a member. But the fame of the institution was certainly not confined to this narrow group. It must be remembered that the people here concerned did not act merely as individuals, but as members of an unofficial corporation of scholars, and that their interests and opinions were freely shared and discussed, as can easily be verified by even a cursory glance at their correspondences from the days of Scaliger to Gassendi and on into the eighteenth century. There was a highly developed *esprit de corps* which made the sharing of information a pleasure as well as a duty, especially in a day when scholarly journals were nonexistent — for the *Journal des Savans* did not begin publication until 1665. It is to be expected, then, that the name and fame of this academy was much more widely spread than is indicated even by the citations above, and it seems important that Tallemant des Réaux should mention it as the most casual thing in the world, without any further explanation.[84] We must also remember that Chapelain, in a letter to Godeau, who was not a member, and hence not to be flattered in regard to it, takes it upon himself to call it "cette illustre Académie." Chapelain was also a close personal friend of three of its members. Marino he knew well, as an habitué of the Hôtel de Rambouillet, and he wrote the preface

[81] Cf. *Lettres de Peiresc*, IV, 61.
[82] *Lettres inédites de Gabriel Naudé* , p. 125. Also cf. note 44.
[83] *Lettres de Peiresc*, V, 370.
[84] *Historiettes*, V, 480.

to his *Adone*, which was published in 1623, apparently after the work had been revised according to Chapelain's ideas.[85] Likewise Tassoni's *La secchia rapita* was published in Paris in 1622 through Chapelain's efforts, after publication had been refused in Italy because of the personalities involved in the poem,[86] and he was a warm admirer of Mascardi's *Trattato dell' arte istorica* and greatly lamented his death.[87] With Cardinal Bentivoglio, also a member of this academy, he carried on a correspondence and greatly admired the cardinal's historical works.[88] Chapelain was influential in three circles – that of Mme de Rambouillet, the more scholarly one of Pierre Dupuy, and the still more important one of the *Académie française*. It is therefore certain that reports concerning his Italian acquaintances would have a wide circulation. It is well to note also in this connection that some of the publications of the *Umoristi* were issued at Paris as well as at Rome.[89] Likewise we must remember that Guez de Balzac, Bouchard, Naudé, and Peiresc were all members at one time or another of the group which met with the Dupuys to discuss scholarly and other news, and it is certain that this "illustrious" academy would be mentioned there, particularly since Bouchard was once so heartily disliked by the Dupuys as to be almost officially excluded from the group,[90] and since this group was itself visited in 1625 by Cardinal Barberini and by Aleandro, both important members of the Roman body.[91]

It is even possible that the French Academy itself was somewhat influenced by its famous Italian sister, and such a thing would not be surprising in view of the foregoing discussion. The fact that Pellisson thinks at once of the uneventful beginnings of the *Umoristi* rather than of some similar body, as a parallel for the casual origins of the *Académie française*, may be due merely to the fact that Naudé's *Mascurat*, from which he takes his information, appeared some two years before he began to write, but it may also indicate that in his mind he saw a closer parallel. This point did not strike Paul Mesnard in his work on the French Academy (1857), or Gaston Boissier

[84] Picco, Francesco, "Appunti alla coltura italiana in Francia nel secolo XVII. Jean Chapelain (1595–1674)," *Miscellanea di studi critici pubblicati in honore di Guido Mazzoni* (Florence, 1907), II. 145.

[86] *Ibid.*, p. 135. [87] *Ibid.*, p. 149. [88] *Ibid.*, p. 151.

[89] See note 41 for an example.

[90] *Lettres de Jean Chapelain*, I. 469, à Balzac, 31 juillet, 1639.

[91] *Peiresc*, I. 59, à Pierre Dupuy, 20 avril, 1625.

(1909),[92] for they go no farther afield in their discussion of origins than the meetings at Valentin Conrart's, but Maylender suggests that the early *académistes* desired to take the name of *Beaux Esprits* in imitation of the original *Begli Humori* of the *Umoristi*. It is doubtful, however, whether this contention could be maintained. Pellisson says merely that "Quelques-uns l'ont nommé depuis *l'Académie des Beaux Esprits*,'[93] and although we know that Guez de Balzac used this name in reference to the body,[94] the term was commonly employed at that period, according to Littré's dictionary, to signify fashionable and somewhat affected literary men, a meaning which Peiresc definitely uses in his letters in 1627, seven years before the official incorporation of the French Academy.[95]

There is, however, a much more definite suggestion, which will not permit us to dismiss this line of thought until it has been completely investigated. Charles Sorel, in his *Discours sur l'Académie française* (Paris, 1654), imputes the general model of the Academy to that outlined by Flurance de Rivault, immediately upon his return from Rome in 1610. "M. Flurance Rivault . . ." he says, "fit imprimer en l'an 1612, le dessein d'une académie et de son introduction dans la cour, . . . mais elle n'eut point d'exécution, et il semble pourtant que notre académie française ait été etablie sur ce modèle, sinon que, comme au lieu du Roi elle n'a eu qu'un cardinal pour protecteur, aussi au lieu des grandes matières de la première elle ne s'est réservé que des questions de grammaire et tout au plus de rhétorique pratique."[96] Although Sorel is an enemy of the Academy and is trying to belittle it, as the quotation plainly shows, his statement is plain, and the obvious inference would be that Rivault, himself influenced by the *Umoristi*, as we have shown, in turn influenced the French Academy. The correctness of Sorel's statement

[92] *Histoire de l'Académie française jusqu'en 1830* (Paris, 1857), *l'Académie française sous l'ancien régime* (Paris, 1909).

[93] *Op. cit.*, p. 18.

[94] *Œuvres*, éd. Conrart, I, 727, à Chapelain.

[95] Peiresc furnishes a much clearer use of the expression in this sense than does the example in Littré, taken from a letter of Balzac to Conrart (2 novembre, 1633) which is referring definitely to the Academy. Peiresc refers (*Lettres*, I, 262, 1627, à Dupuy) to the *Recueil des lettres nouvelles* put together by Faret (Paris, 1627, 8°) as follows: "verray . . . trez volontiers ce recueil de lettres des beaux esprits quand ce ne seroit que pour l'amour de Mr de Malerbe, qui est bien de mes amys."

[96] Cited by Livet in his edition of Pellisson et Olivet, *Histoire de l'Académie* . . ., I, 476.

cannot be examined at this time because of the inaccessibility of the work, which apparently is not to be found in America. It opens up, however, an interesting vista of investigation on which I hope to report at another time.

It is evident from the facts presented that the *Umoristi* were a large and important organization in seventeenth-century Rome, that they had many celebrated personages among their members, and that their gatherings were large and brilliant, the most magnificent being probably the funerals held in honor of former presidents. We have also seen that a certain number of Frenchmen, mostly scholars or of scholarly inclinations, were members, and that through their connections in France and the connections of certain Italian members this body must have been well known in Paris, certainly among the group of savants gathered about Pierre Dupuy, which contained several members of the French Academy. In particular we have shown that one French member of the *Umoristi*, inspired by his recent election to the body, wrote a book which Sorel claims to be the model outline of the organization of the French Academy. If this statement can be shown to have truth, then it would seem that indirectly, perhaps even unconsciously, the *Académie française* itself owes some debt to the *Accademia degli Umoristi*.

University of Michigan

SHELLEY'S *BIBLICAL EXTRACTS* A LOST BOOK

BENNETT WEAVER

I

THE influence of Godwin and the French philosophers upon the growing Shelley was great, but it has, I think, been sufficiently insisted upon. Were one selecting a work to illustrate this influence he would doubtless choose *Queen Mab*. However, as he entered into a study of that document, which concerns itself "with moral and political speculation, as well as the subtler discriminations of metaphysical and religious doctrine,"[1] he would be arrested by the fact that the young man was compiling a work called *Biblical Extracts* at the same time that he was composing the poem. He would observe, also, that the *Biblical Extracts* and the poem were both completed before "the long and philosophical notes" attached to *Queen Mab*, notes which carry evidence of the author's interest in Godwin and the French,[2] were finally assembled. Not, then, desiring to belittle a patent influence ensealed in scholarly tradition, he would, nevertheless, wish to study the evidences of a supplementary Biblical influence and to hypothesize the contents of the lost book. For the *Biblical Extracts*, lost in reality, seems lost almost as completely by critics of Shelley.

[1] Letter to Leigh Hunt, June 22, 1821.

[2] Dating our selections before May, 1813, in that time when Shelley was devouring Godwin, Condorcet, D'Holbach, Diderot, Helvétius, Rousseau, and Voltaire, let us notice certain sharp qualifications of his enthusiasm.

(a) Letter to Thomas Jefferson Hogg, May 15, 1811. "The 'Confessions of Rousseau' . . . are either a disgrace to the confessor, or a string of falsehoods, probably the latter."

(b) *Proposals for an Association*, pp. 13–14 of 1812 edition. "Voltaire was the flatterer of kings, though in his heart he despised them — so far has he been instrumental in the present slavery of his country. Rousseau gave licence by his writings, to passions that only incapacitate and contract the human heart — so far hath he prepared the necks of his fellow-beings for that yoke of galling and dishonourable servitude, which at this moment, it bears."

(c) In the *Proposals* he writes further: "Helvétius and Condorcet established

I propose, therefore, to do four things. First (in point of chronology, of substance, and of purpose), to examine what Shelley wrote regarding the *Biblical Extracts* and *Queen Mab*, second, to examine those two major documents which he wrote immediately before and only five days after he first contemplated making the *Extracts*, namely, *An Address to the Irish People* and *Proposals for an Association*, third, to observe any actual deposits of Biblical materials in *Queen Mab*, and fourth, to offer a hypothetical suggestion regarding the contents of the lost book.

It is in the letters of Shelley that we find the record of the simultaneous preparation of *Queen Mab* and the *Biblical Extracts*. By placing in parallel columns what he wrote we may make clear not only the significant simultaneity of the two works, but something of their common purpose. All the entries in both columns illustrate the first point, whereas only some of them illustrate the second. It seems best to retain them all, however, for although they cannot prove a similarity in the substance of the two completed documents, they do point toward a probable consentaneity of purpose.

Biblical Extracts

1 *To Elizabeth Hitchener*, Feb 27, 1812

"I have met with some waverers between Christianity and Deism. I shall attempt to make them reject all the bad, and take all the good, of the

Queen Mab

1 *To Elizabeth Hitchener*, Feb 14, 1812

[Speaking of Time. Cf. Rev 6 2.] "Proceed, thou giant, conquering and to conquer! March on thy lonely way. — The Nations fall

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principles, but if they drew conclusions, their conclusions were unsystematical, and devoid of luminousness and energy of method."

(*d*) Letter to William Godwin, July 29, 1812. "It is a book [D'Holbach's *La Système de la nature*] of uncommon powers, yet too obnoxious to accusations of sensuality and selfishness. — In fact the doctrine which affirms that there is no such thing as matter, and that which affirms that all is matter, appear to me perfectly indifferent in the question between benevolence and self-love." It is "this materialism" which in his essay *On Life* (1815) Shelley later denounced as "a seducing system to young and superficial minds." In his maturity he wrote to Horace Smith on April 11, 1822. "The doctrines of the French and material philosophy are as false as they are pernicious."

(*e*) Letter to Elizabeth Hitchener, June 11, 1811. "A picture of Christ hangs opposite in my room. It is well done, and has met my look. Do not believe but that I am sincere."

(*f*) Thomas Jefferson Hogg, *Life of Shelley*, II 458. "He certainly was at all times prone to discuss, to attack, or defend the curious speculations which abound in the writings of William Godwin, and of divers French authors of that age, but he never seriously and in good earnest adopted their startling and unhealthy paradoxes."

Jewish Books I have often thought that the moral sayings of Jesus Christ might be very useful, if selected from the mystery and immorality which surrounds them, it is a little work I have in contemplation"

2 *To Thomas Hookham*, Dec 17, 1812

"You will receive the 'Biblical Extracts' in a day or two by the twopenny post I confide them to the care of a person going to London Would not Daniel I Eaton[3] publish them? Could the question be asked him in any manner?'

3 *To Thomas Hookham*, Jan 2, 1813

"I think that the type and size of Godwin's Essay on Sepulchres would be a good model for The Biblical Extracts At all events I would wish them to be sent to the press If you cannot have access to Eaton 250 copies will suffice Small Christmas or *Easter offerings* of a neat little book have frequently a surprising effect The Emperors of China seem to form a singular exception to the usual doltishness of the regal race I sympathize with his imperial majesty, but might not a preface be as efficacious in preventing the circulation of Biblical poison as a penal law?"

4 *To Thomas Hookham per Harriet*, Jan 31, 1813

"In reading the Paper I perceive that Coleridge has just published a

beneath thy noiseless footstep—pyramids that for millenniums have defied the blast and laughed at lightnings, thou dost crush to nought Yon Monarch in his solitary pomp is but the fungus of a winter day that thy light footstep presses into dust Thou art the conqueror, Time! all things give way before thee but 'the fixed and virtuous will, the sacred sympathy of soul which was when thou wert not' (Cf *Queen Mab* IX, 23 37)

2 *To Thomas Hookham*, Aug 18, 1812

"I enclose also by way of specimen all that I have written of a little poem begun since my arrival in England I conceive I have matter enough for 6 more cantos The Past the Present, and the Future are the grand and comprehensive topics of this Poem I have not yet half exhausted the second of them"

3 *To Thomas Hookham*, Jan 26, 1813

'I expect to have Queen Mab, and the other Poems finished by March Queen Mab will be in ten cantos and contain about 2800 lines The other poems probably contain as much more. The notes to Q M will be long and philosophical I shall take that opportunity which I judge to be a safe one of propagating my principles, which I decline to do syllogistically in a poem A poem very didactic is I think very stupid

4 *To Thomas Jefferson Hogg*, Feb 7, 1813

"'Mab' has gone on but slowly, although she is nearly finished

[3] It was Eaton whose "unmerited suffering" Shelley decried in *A Letter to Lord Ellenborough* Eaton had been persecuted for publishing the Third Part of Tom Paine's *Age of Reason*. See Shelley to Godwin, June 11, 1812

play called Remorse I wish you to send us two copies of it also a copy of the Rejected Addresses [J and H Smith, 1812] and one of Campbell's Gertrude of Wyoming *for a neighbor of ours* Mr Shelley hopes to find some copies of the Biblical Extracts in the Box"

They have teased me out of all poetry"

5 *To Thomas Hookham*, undated, *circa* June, 1813?

"You will receive a parcel directed to me at your House Open it and you will find the Essay on Atheism, Queen Mab, and the Biblical Extracts Keep the former for yourself (it is the only one I have) and send the others carefully packed by Mail directed to be forwarded with *care* and *speed*"

5 *To Thomas Hookham*, Feb 19, 1813

"Queen Mab is finished and transcribed I am now preparing the Notes[4] which shall be long and philosophical You will receive it with the other poems I think that the whole should form one volume, but of that we can speak hereafter"

Even while remembering that we have here only incomplete data kept by the salvage of chance, we must observe certain matters presented in these parallel columns The first and the most important of these is that the chronologies are closely interlocked It is only thirteen days after the prose phrasing of certain ideas which later were to appear in *Queen Mab* that Shelley tells Miss Hitchener he has "often thought" of and has in contemplation a work which became the *Biblical Extracts* Though in August of 1821 he has "not yet exhausted the second" canto of the poem, by December of the same year he has obviously completed the prose compilation He does not finish the poem itself until at least sixty-four days after he has the "little work" in readiness for the publisher In view of the fact that there is a possible correlation between priority and influence, it is interesting to balance the probability of the influence of the Biblical material upon the poem against the probability of the influence of the somewhat Godwinian and French notes, which were not completed until four months after *Queen Mab* was finished It is at least fair to raise a question of the relative significance in Shelley's mind during the actual writing of the poem (February 27, 1812 — February 19, 1813) of the material in the *Biblical Extracts* which had been considered and ordered and the material of the notes

[4] Shelley was still at work on the notes in March, 1813, when he sent the poem to Hookham The poem and the notes together were brought to press only a little before May 21, 1813 See Harriet to Mrs. Nugent, May 21, 1813

which, however much it may have been considered, had not been ordered. It would be easy to press this matter too far, for to do so implies a pertinent antithesis between the materials which may not indeed exist. I should not raise the point were it not for Shelley's having in a manner suggested it by confiding to Hookham that the notes were not necessarily integral with the poem, but that the poem, itself not "very didactic," was to be the means of carrying out to the world his principles, rather slyly attached, as was Ulysses to the belly of the ram. "I shall take that opportunity," says the wily author, "which I judge to be a safe one of propagating my principles, which I decline to do syllogistically in a poem."

If it is not to overweight the argument — for I by no means wish to insist upon the Biblical materials' being antithetical to the material in the notes, since the question is not one of antithesis but of proportional supplementation — I would now observe that the works which were in preparation at the same time were *Queen Mab* and the *Extracts*, not the notes, *Queen Mab*, and the *Extracts*. There is no mention of the notes until forty days after the completion of the Biblical compilation. The notes, then, need not be deeply involved in the consideration of the fact that the two other works, being written at the same time, were prepared largely in the same spirit and with the same purpose. There is no suggestion of Shelley's being aware of anything contrasting or destructively opposite in "all the good of the Jewish Books," in "the moral sayings of Jesus Christ," and that good and that morality which he had before him in writing the poem. To raise this question in the presence of Shelley's intelligence is to answer it finally. Indeed he knew well enough that embedded within the Bible was just that material which would hit early nineteenth-century "Christianity" the hardest blow, and would hit in the same vital place where he intended his poem to strike. In contesting for the poet's sensitiveness to Biblical precepts I would hardly go so far as to maintain that he did not let the right hand of his poetry know what the left hand of his compiling did.

II

It will now aid our speculation if we glance at the Irish documents which Shelley "gave to the world" immediately before and after his first contemplating the *Biblical Extracts*. This examination although cursory will, I think, suggest to us the legitimate genesis of his plan

To begin with, we may assume that Shelley had long been familiar with the Bible, although not so intimately in his earlier as in his later years[5] Further we may note that in the early part of 1812,[6] when he was preparing his *Address to the Irish People*, he not only dramatized himself as an apostle but, unless I am mistaken, he consciously and purposefully adopted certain of the simplicities and nuances of Paul's language It will be remembered that the great parvenu had said (II Cor 11 29, 12 10, I Cor 9 1) "Who is weak, and I am not weak?" "When I am weak, then am I strong", "Am I not an apostle?" So Shelley cries out to the sister of his soul, Elizabeth Hitchener "I — even I, weak, young, poor as I am — will attempt to organize them, the society of peace and love Oh! that I may be a successful apostle" And just as Paul admits to the Corinthians that he has treated them as "babes," to be fed "with milk, and not with meat" (I Cor 3 1–2), so Shelley confides

[5] (*a*) Percy Bysshe Shelley, note vii (ll 135–136) on *Queen Mab* "A book is put into our hands when children, called the Bible "

(*b*) Adolph Droop, *Die Belesenheit Percy Bysshe Shelley's*, p 7 "Die Bibel war eines der liebsten Bücher des 'Atheisten' Shelley In Tanyrallt macht er Auszüge aus der Bibel, in der Absicht, sie herauszugeben "

(*c*) Mary Shelley, note on the poems of 1816 "It was his frequent habit to read aloud to me in the evening, in this way we read, this year, the New Testament '

Note on the poems of 1817 "In English, the Bible was his constant study, he read a great portion of it aloud in the evening."

Note on *The Revolt of Islam* "To these [the poets] may be added a constant perusal of portions of the Old Testament — the Psalms, the Book of Job, the Prophet Isaiah, and others, the sublime poetry of which filled him with delight " [Cf also Mary Shelley's note on *Prometheus Unbound*]

Her *Journal* in *Shelley and Mary*, n p , n d , Vol II (1820)

"*Saturday, Jan 1* — Read Livy, work Shelley reads the Bible, Sophocles, and the Gospel of St Matthew to me" (p 467)

"*Wednesday, Jan 5* — Shelley reads Sophocles, the Bible, and 'King John ' Finish Proverbs, Ecclesiastes, and Solomon's Song" (p 471)

"*Wednesday, Feb 2* — Shelley returns from Leghorn, he reads Isaiah aloud to me" (p 473)

"*Tuesday, March 24* — Shelley finishes the 'Leviathan' of Hobbes, reads the Bible aloud" (p 483)

I am including only these entirely authoritative statements, although I would fully credit in this matter the statements of Hogg, Medwin, Hunt, and Dowden

[6] The first mention of the *Address* stands in a letter to Elizabeth Hitchener, January 20, 1812. This work was being printed on February 20, 1812, just seven days before Shelley wrote to Miss Hitchener that he had "often thought" of compiling the *Biblical Extracts* The *Proposals* did not leave the press until March 4, or five days after he had had the other "little work in contemplation."

that in writing the *Address* he took "pains that the remarks which it contains should be intelligible to the most uneducated minds — In so doing I have but translated my thoughts into another language" That other language, I do not doubt, was the language of St Paul and of the great Teacher whom Paul emulated

Beyond the matter of language it is to be observed that the principles which Shelley conveys to the Irish are in many respects drawn forward either directly or indirectly from the Sermon on the Mount His statesmanship, which has suffered no fatal divorce from "ethical science," [7] is briefly this To win freedom be pure in heart, resist no evil, love your enemies, and in that love bring peace Upon these basic appeals the countless changes are rung, and he who runs may hear them throughout the documents

I stress this matter because I want to make it patent that Shelley is drawn by intense passion to one single purpose at the very time he conceives of his poem and contemplates his compilation, and it were a strange thing indeed if, set in a single purpose, he should write a poem largely to promulgate Godwinism and French philosophy, and compile the *Biblical Extracts* to disseminate "all the good of the Jewish Books," or "the moral sayings of Jesus Christ"

III

In turning to *Queen Mab* I should like, first, to consider the general similarities in principle existing between the poem and the traditional convictions of the Hebrews and, secondly, to note any specific similarities existing between the poem and the Bible It is in a general way true that the passion for social righteousness so warm in the young poet was traditional among the prophets and with Jesus They, too, cried out against oppression and for brotherhood, they, like Shelley, tended to objectify oppression in certain functionaries and institutions It was natural that the nomadic Hebrews coming in contact with the more commercial peoples established in cities along the trade routes of Palestine should in moments of high racial consciousness be critical of the ways of the Philistines And as the Hebrew race began to lose its identity through inevitable fusion with the "heathens," it was natural that the more inspired of those to

[7] Letter to Elisabeth Hitchener, January 7, 1812 "The most fatal error that ever happened in the world was the separation of political and ethical science"

whom the laws of the tribal Jehovah were precious should speak against the evils of the latter days The basic racial conflict was often objectified in prophetic charges made against local baals (owners or lords) maintaining themselves richly in a commercial civilization supported by sympathetic ecclesiastical, judicial, and military groups In brief, the prophet of the true God, being at heart a nomadic tribesman, spoke fiercely against kings, princes, and the rich associated with them He attacked judges who were not merely elders of the tribe called upon to see that man should deal justly with man, but who were specialized functionaries manipulating an intricate legal system for the convenience of the powerful With a peculiar and an instinctive antagonism he attacked priests who were the ecclesiastical supporters of monarchy and "things as they were" Having sensed how the oppressor maintained himself on the one hand by controlling the administration of earthly laws and on the other by regulating the ministrations of the heavenly, he poured his wrath upon the tyrant, withheld himself from the "red slayer," and anticipated those times when war, the great instrument of the tyrant, should be no more Finally, being caught by despair over the insouciance of men, the prophet sublimated his dark agony into a philosophy of love

I submit that these antagonisms and this sublimation were essentially the same as those of Shelley I do not suggest that he derived his convictions or his hopes entirely from the Scriptural source, or to any exact degree from that source Shelley was Shelley There was, too, a French revolution, and there were philosophies of that revolution The young poet knew these philosophies, and in 1812 and 1813 he seemed to respond in some measure to them Further, many of the tenets of these philosophies cannot be sharply distinguished from certain principles of the prophets It is a mixed matter Yet it is difficult to avoid concluding that there are general similarities in principle existing between the young poet and the prophets [8]

This conclusion can only be supported by a glance at the Biblical

[8] These similarities will be made clear by the following parallel readings I Samuel 8 10–18, and *Queen Mab* III 30–33, 57–60, 118–122, IV 237, 245 Amos 6 1, 4, 6, 3 15, 9 2, Isaiah 3 15, 5 8, and *Queen Mab* V 53–60 Zephaniah 3 3, Amos 2 3, Micah 7 2, 3, and *Queen Mab* IV 196–207 Hosea 6 9, Malachi 2 1, 8, and *Queen Mab* VII 44–46, IV 104–107 Isaiah 2 4, and *Queen Mab* IV 168–169

materials used more directly in the poem Although it may justly be felt that some of the following parallels are little more than commonplaces, yet if there does exist any real parallelism between what Shelley may have been collecting into his *Biblical Extracts* and what he was writing into *Queen Mab*, then we must give it consideration

	The Bible		*Queen Mab*
1	" And now also the axe is laid unto the root of the trees therefore every tree which bringeth not forth good fruit is hewn down " — Matt 3 10	1	Let the axe Strike at the root the poison tree will fall " — IV 82–83
2	" the pestilence that walketh in darkness " — Ps 91 6	2	The pestilence that stalks In gloomy triumph " — IV 188–189
3	"The Spirit of the Lord is upon me, because he hath anointed me to preach the gospel to the poor " — Luke 4 18	3	"Look to thyself, priest, conqueror, or prince! Whether thy trade is falsehood and thy lusts Deep wallow in the earnings of the poor, With whom thy Master was " — IV 237–240
4	"One generation passeth away, and another generation cometh but the earth abideth for ever " — Eccles 1 4 [For the complete quotation of Eccles 1 4–7, see Shelley's note]	4	"Thus do the generations of the earth Go to the grave, and issue from the womb, Surviving still the imperishable change That renovates the world " — V 1–4
5	" a perfect and just measure shalt thou have " — Deut 25 15	5	"In just and equal measure all is weighed " — V 235
6	"The fool hath said in his heart, There is no God " — Ps 14 1, 53 1	6	"'Weep not, child!' cried my mother, 'for that man Has said, There is no God '" — VII 12–13
7	" he [Moses] slew the Egyptian " — Exod 2 12	7	"A murderer heard His voice in Egypt " — VII 100–101
8	[See Gen 1–3]	8	"From an eternity of idleness

	I, God, awoke, in seven days' toil made earth From nothing, rested, and created man I placed him in a Paradise, and there Planted the tree of evil, so that he Might eat and perish" — VII 106–111
9 [In the footnotes to *A Refutation of Deism* Shelley has left an ample record of his reading the Hebrew history of the conquest]	9 "Here I command thee hence to lead them on, Until, with hardened feet, their conquering troops Wade on the promised soil through woman's blood" — VII 117–119
10 [Shelley's note on this passage, too long to be entered here, contains Biblical material which obviously should be used in a parallel study]	10 "One way remains I will beget a Son, and He shall bear The sins of all the world, He shall arise In an unnoticed corner of the earth, And there shall die upon a cross, and purge The universal crime ' — VII 134–139
11 For many are called, but few are chosen" — Matt 22 14	11 "Many are called, but few will I elect" — VII 156
12 " he treadeth the winepress of the wrath of Almighty God" — Rev 19 15	12 "Drunk from the winepress of the Almighty's wrath" — VII 218

In *Queen Mab* the verbal echoes from the Bible and the ideas borrowed from it, ranging as they do from Genesis to Revelation, not only enhance the significance of the more general similarities, but also support the thesis that in writing the poem Shelley did not divorce his mind from the Biblical material over which he was simultaneously working However light or weighty one may think these similarities to be, they should make it unnecessary any longer to regard the poem as largely a versification of Godwinian and French philosophies

IV

We now come to an interesting speculation What did the *Biblical Extracts* contain? I wish to draw my suggestion from two

tables Table I indicates the number of instances in all Shelley's work — romances, letters, notes, prefaces, essays, poems, and prose and verse fragments — in which he in some manner either employs Biblical material or makes reference to the Bible These instances are registered according to books, preference is given to the more probable book when two are involved and to the most probable when more than two are involved In establishing the preference accuracy can sometimes be no more than approximated Furthermore, the instances are arranged in six columns under six heads, the first three of which respectively indicate that some idea from the Bible is used and approved, or used but disapproved, or used in a neutral way The last three, in order, indicate references favorable to an idea, or unfavorable, or neuter * In the first three columns there is either a direct use of Biblical language or in some few instances an indirect use of it For the sake of compactness I have included in the tabulation only those books the materials of which have been used or referred to at least five times

* In order that these classifications may be the clearer, I wish in each case to offer a type illustration I select these from the prose although the principle of classification is the same in the poetry The symbols are explained in connection with Table I

1 + "Depend, then, not upon the promises of Princes" — *Address to the Irish*
"Put not your trust in princes" — Ps 146 3

2 – "I will admit that one prediction of Jesus Christ has been indisputably fulfilled I come not to bring peace upon earth, but the sword" — *A Refutation of Deism*
"I came not to send peace, but a sword" — Matt 10 34

3 0 "You are 'the deaf adder that stoppeth her ears, and harkeneth not to the voice of the charmer' — Letter to Elizabeth Hitchener
"They are like the deaf adder that stoppeth her ear, Which will not harken to the voice of charmers" — Ps 58 4–5

4 R + "Even when recommending Christianity you cannot forbear breathing out defiance, against the express words of Christ" — Letter to Robert Southey
I assume that the reference here is to Matt 5 44 "Love your enemies"

5 R – "The loathsome and minute obscenities to which inspired writers perpetually descend might corrupt, were they not so flagitious as to disgust" — *A Refutation of Deism*

6 R 0 "It describes the result of my battle with their Omnipotent God, his pulling me under the sea by the hair of my head, like Pharaoh" — Letter to C and J Ollier
Reference Exod 14 28

TABLE I

COMPLETE LIST OF BIBLICAL PASSAGES USED OR REFERRED TO BY SHELLEY

P — Prose	0 — Idea used in a neutral way
V — Verse	R + — Favorable reference to an idea
+ — Idea used and approved	R − — Unfavorable reference to an idea
− — Idea used but disapproved	R 0 — Neutral reference to an idea

OLD TESTAMENT *	+	−	0	R +	R −	R 0
Genesis	1 P	1 V	6 P 12 V	2 P	4 P 1 V	4 P 2 V
Exodus	1 P	2 P	3 P		2 V	1 P 1 V
Deuteronomy	1 P 1 V	2 P	1 V		1 P	
Joshua		2 P			2 P	1 V
I Chronicles			1 P 1 V			2 P
I–II Samuel	1 P	1 P	2 V		3 P	
I–II Kings			3 P 2 V			1 P 2 V
Job	1 P 3 V	1 P	8 P 9 V	2 P	1 V	1 P 1 V
Psalms	5 P		6 P 8 V			
Ecclesiastes	2 P 4 V	2 P	11 P 3 V			1 V
Isaiah	7 P 4 V		2 P 2 V			2 P
NEW TESTAMENT †						
Matthew	41 P 22 V	4 P 2 V	35 P 32 V	10 P 1 V	3 P 2 V	3 P 2 V
Mark	2 V		3 P 2 V		2 P	
Luke	3 P 3 V	2 P	10 P 8 V	2 P	2 P 2 V	
John	4 P 6 V	1 P	11 P 5 V	3 V	4 P	1 V
Acts	4 P		1 P 2 V	1 P		
Romans	1 P	1 P	1 P 1 V			1 P
I Corinthians	6 P 1 V	1 P	1 P 5 V			
Galatians	4 P 1 V		1 P			1 V
Revelation	1 P		4 P 12 V			

* In addition results for the following books are indicated Numbers − 1 P 0 1 V Proverbs 0 2 P Song of Solomon 0 1 V, Ezekiel 0 1 P 1 V R − 2 P Daniel 0 1 P, Hosea R − 2 P Amos + 1 V, Micah + 1 P, − 1 P 0 1 V Including these figures with those given in the table for the Old Testament we have the following results 107 P 68 V, total 175

† In addition results for the following books are indicated Ephesians 0 1 V, Colossians + 2 P − 1 P Philippians + 1 P, Titus + 1 P + 1 V Hebrews + 1 V 0 1 P, I Peter + 1 P 0 1 P I John + 1 P + 1 V, James + 2 P 0 1 P Including these figures with those given in the table for the New Testament we have the following results 180 P 120 V, total 300 The grand totals of Table I are for prose 287 for verse 188 and for both prose and verse 475

If, now, alike from the Old Testament and from the New we select the five books indicating the greatest use and reference, we shall have the basis for Table II This table indicates the number of times the various chapters of the most highly preferred books are in some part used or referred to, either in a neuter or in a favorable way From this table the negative has been excluded It shows us, then, rather specifically the preferred portions of the preferred books, and may serve as the basis for the speculation which we wish to make I hasten to say, however, that I do not think that we can regard the mere number of uses and references as anything more than indicative As we are familiar with Shelley's fondness for both Isaiah and Job the tabulation will, at these points, seem to declare its inadequacy There is also the question which must be raised about the accuracy of using materials from works written after the *Biblical Extracts* was prepared The expedient, even though it is qualified by retrosupposition, appears to me to have this in its favor It offers us a much more ample body of data than would the consideration of those few letters, documents, and poems written before December 17, 1812, and, further, it does not seem to involve us in a contradiction of any of those Biblical influences becoming apparent before that time, but seems rather to strengthen our conclusions It does not, I believe, change essentially but rather fulfills the proportions of those influences Finally, I am including the entire Bible in the investigation since this procedure will satisfy the condition of Shelley's having used "all the good of the Jewish Books" "The moral sayings of Jesus" can easily be placed within the larger frame

Reverting to Shelley's first mention of the *Biblical Extracts*, we recall that two different works were adumbrated The first was intended to make the waverers between Christianity and Deism "reject all the bad, and take all the good, of the Jewish Books" [10] The second was less ambitious, "a little work" designed to present "the moral sayings of Jesus Christ selected from the mystery and the immorality which surrounds them" If we study our table with a view to determining what the larger work might have been, we may in a general way feel that the data corroborate what we should

[10] *The Refutation of Deism* (1814) would seem in part to meet this design It is at least specific and pronounced in rejecting some of "the bad of the Jewish Books"

TABLE II

List of Biblical Passages Chiefly Used by Shelley

Old Testament	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24*
	Chapter																							
Genesis	4P 5V		5P 3V	3P 4V	1V				1V		1P													
Job	2P 1V	3P 6V	2V	2P										1P						1V	1P			
Psalms					1V	1P	2V	1P			1P			1V										
Ecclesiastes.	7P 3V		1P 1V	1P 1V			2P		1P 1V			1P 2V												
Isaiah	2P 1V	1P 1V	1P				1V				3P 1V													
New Testament																								
Matthew	1P		3P 1V	1P	23P 15V	8P 3V	10P 3V	2P 4V	1P 1V	3P	4P	4P	3P 1V	1P 1V	1P 1V	1V	1P 2V	1P 2V	3P 2V	1P 1V	2V		8P 2V	1P
Luke		2P	1V				1V			2P		2P	1P 1V			3P 1V			1P	1P	1V	1P 2V	2P 4V	
John	3P 1V		3P 2V	2P 2V		1V	1P	4P 1V		1V	1V		2P 1V		1V		1V		2V		1V			
I Corinthians.		1V						2P					4P 1V		4V	1P								
Galatians	1P		2P		2P	1V																		

* The references beyond Chapter 24 are Job 31 1 V 38 3 P 39 1 P 41 1 P Psalms 36 1 P 57 1 P 1 V 90 1 P 91 3 V 103, 2 P 130 1 P 140 1 P 146, 1 P Isaiah 34, 1 P 35 1 P 53 1 P 2 V Matthew 26 2 P 7 V 27 7 P 8 V

naturally expect In the Old Testament, as Mary Shelley specified in her note on *The Revolt of Islam*, it was "the sublime poetry of the Psalms, the Book of Job, the Prophet Isaiah" which "filled him with delight" His "constant perusal" of Job led him, in his *Essay on Christianity*, to refer to it as "the sublime dramatic poem" which had familiarized the imagination of Jesus Christ "with the boldest imagery afforded by the human mind" Ecclesiastes, he further felt, "had diffused a seriousness and solemnity" over that same divine imagination I should, however, question the inclusion of Genesis since it is largely the material of Chapters 1, 3, and 4 which engaged his mind, and that in a way distinctly neuter So far as the Old Testament is concerned, therefore, I should suggest that the *Biblical Extracts* might have included Job and Ecclesiastes entire, a considerable selection from Psalms, and those chapters of Isaiah which are spiritually the most imaginative or which are warmest with the essential social passion of the prophets If materials from the New Testament were used, I should suggest that beyond a synthetic selection from Matthew, Luke, and John there might have been passages culled from the Pauline epistles, those passages particularly in sympathy with the "sayings of Jesus Christ," of which I Corinthians 13 would be an example The omission of James in the New Testament is as difficult to account for as the omission of Amos in the Old

If, however, we study the table with a view to determining what the "little work" might have contained, we may feel more certain of our conclusions First, we are told that it is to contain only "the moral sayings of Jesus Christ selected from the mystery and the immorality which surrounds them" The work, then, will not include anything outside the Gospels, and it will not, in all probability, include anything from Mark, which seems to have left Shelley's imagination cold The nuclear book in the synthetic study will be Matthew John will be used to supplement the more spiritual parts of Matthew, as will those parts of Luke which are free from the mystery of the virgin birth and the miracles The core of the compilation will be the Sermon on the Mount I would say, to be as definite as I can be in a brief way, that the Sermon would be the touchstone by means of which material would be tested for either inclusion or exclusion from the *Biblical Extracts* The data of Table II indicate in part the material that had the greatest proba-

bility of being included,[11] and that, as I have said, is the material of Matthew 5–7.

It is my opinion that if the *Biblical Extracts* are recovered they will be found to be the "little work," and that the "little work" will contain principally a synthesis of "the moral sayings of Jesus Christ," just as Shelley wrote. And were it such a work it would aid us not only in understanding some of Shelley's inspiration in writing *Queen Mab* but in understanding better the full development of his social and poetic genius.

University of Michigan

[11] I would invite especial attention to the parallel study of the Gospels begun in Shelley's notebooks now in the Huntington Library.

CLINICAL SERVICE AT WESTERN STATE TEACHERS COLLEGE

HOMER L. J. CARTER

FROM October, 1931, to October, 1933, sixty problem children were referred to Western State Teachers College for study. In view of this responsibility the first aim of the clinic is service to the community, the second is cooperative research on the part of faculty members, centering not only upon diagnosis but remedial treatment as well, and the third is the training of a limited number of competent students in dealing with psycho-educational problems which, perhaps because of mass instruction and social and economic stress, seem to be increasing in number.

INCIDENCE AND SOURCES OF CASES STUDIED

The sixty cases mentioned were referred from the public schools, parents, relatives, and social and health agencies in areas adjacent to Kalamazoo. Tables I and II show distributions of chronological and mental ages of these children. Table III presents a distribution of I. Q.'s for the same group. In Table IV are listed the most common complaints in order of frequency. In several cases two or more difficulties were associated.

PROCEDURE FOLLOWED IN DEALING WITH CASES

Problems of various types of maladjustment referred to the clinic are first handled by the Department of Research. In each case a careful and somewhat detailed history is obtained which consists of (1) a definite statement of the problem, (2) family history, (3) developmental and medical history, (4) school history, and (5) clinical data comprising anthropometric and educational measurements, results of Binet and performance tests, and, in certain cases, reports of psychiatrist, physician, or eye specialist. After the case history is fairly well completed the problem is referred to some member or members on the staff best fitted by training and experience to handle

TABLE I

Distribution of Cases by Chronological Age

C A	*Frequency*	*Percentage*
18–20		
15–17	8	13
12–14	21	35
9–11	19	32
6 8	12	20
3–5		
Total	60	100

TABLE II

Distribution of Cases by Mental Age

M A	*Frequency*	*Percentage*
15–17	5	9
12–14	15	25
9–11	23	38
6–8	15	25
3–5	2	3
Total	60	100

TABLE III

Distribution of Cases by Intelligence Level

I Q	*Frequency*	*Percentage*
Above 130	1	2
110–129	11	18
90–109	25	41
70–89	18	30
Below 70	5	9
Total	60	100

TABLE IV

Classification of Cases Studied

Type of difficulty	*Frequency*
Reading deficiency	31
Physical defects	7
Mental retardation (marked)	7
School retardation (could be applied to most cases)	5
Arithmetic difficulties	2
Spelling deficiencies	2
Classification	7
Social maladjustment	6
Speech defects	3
Nervousness	2
Marked malnourishment	1

Classification of Cases Studied (*Continued*)

BEHAVIOR	27 (total)
Stealing	2
Disobedience, rebelliousness, etc	5
Fighting, bullying	2
Laziness	2
Dislike for school (attitude)	5
Setting fires	1
Need for sex education	1
Mother dominance or pampering	3
Flighty attention	4
Temper	1
Irregular school attendance	1

it Some cases are dealt with by faculty members only, and others are assigned to certain students who make home visits, gather data from various sources, and carry out remedial suggestions under the direction of the staff adviser

After sufficient study of the problem has been made, and after written consent of the parents or guardian has been obtained, the case is reviewed at a staff meeting All information available is presented by the faculty member in charge or by a student under his supervision Frequently the child is brought before the group for questioning and for the purpose of demonstrating certain abilities, disabilities, and reactions An attempt is made to formulate a tentative diagnosis and to outline remedial procedures Stenographic records of these meetings are kept for each child studied The staff recognizes four major types of cases those in which (1) the main responsibility should be carried by some faculty member alone, (2) the responsibility for diagnosis and treatment should rest with a psychiatrist, (3) careful study is required, but with remedial treatment left in the hands of parents, teachers, or social worker, and (4) various forms of advisory service are required

TENTATIVE EVALUATION

No objective criteria of satisfactory adjustment have been set up for the evaluation of remedial treatment However, the term "satisfactory adjustment" has been used to indicate that the original problem of the child has disappeared and that a normal relationship has been established, "partial adjustment" in cases in which the basic problem was cleared up, but in which certain new problems

arose to threaten normal relationships between the child and his environment, "unimproved" to indicate that the underlying causes of the maladjustment have not been removed or modified by treatment In problems involving educational maladjustment, objective measures are given to indicate growth, but in the so-called behavior problems judgments given by parents and teachers are the only means of evaluation and these at best are subjective Of the sixty children studied at Western State Teachers College 25 per cent were, according to these standards, satisfactorily adjusted, approximately 52 per cent were partially adjusted, and 23 per cent showed no improvement whatsoever Similar results, evaluated in much the same manner, are reported by Lowrey and Smith at the Institute for Child Guidance in New York City[1]

INTRODUCTION

A reading case classified as "partially adjusted" was referred to the staff by a father because of his son's unsatisfactory work in history and geography and because of his inability to read The case is briefly summarized as follows

John is a likable boy, thirteen years and seven months of age He has a quiet, retiring disposition and is as much at ease when conversing with strangers as with friends He is very sensitive, easily offended, and appears quite lacking in a desire to fight for his place He is well mannered and has none of the boisterous traits that are often characteristic of his age He is passively interested in boys as playmates, but likes scouting activities and out-of-door sports His home is one of the best in the city, and his mother and father, who are both college graduates, are interested in the welfare of their children

INTELLIGENCE AND FACTORS AFFECTING PERFORMANCE

A brief summary of clinical data indicates average intellectual capacity The mental age, as determined by the Binet-Simon, is fifteen years and one month and the intelligence quotient is 112 The form boards as well as the Binet show average innate capacity On these tests his median mental age is fourteen years and the median percentile is fifty Scores on the Knox Cube Test, substantiated by

[1] Lowrey, L G, and Smith, Geddes, *The Institute of Child Guidance, 1927–33*, The Commonwealth Fund (New York, 1933), p 56.

later tests, suggest poor visual memory Both right and left hands were used in completing the form boards, and in two instances reversals were made on the Cube Test Foresight and caution may be inferred from the results of the Porteus Maze Superior ability to analyze a situation and to sense relationships is suggested by achievement on the Healy Pictorial II The Gates Perception Tests[2] indicate normal ability to perceive and select geometrical figures However, extremely low scores were obtained on the tests involving the perception of digits and words With the exception of these tests the measures indicate average performance and suggest ability to do satisfactory academic work

A study of family history, home conditions, developmental history, and present health status shows no factors which in any way interfere with the child's ability to do satisfactory school work Visual and auditory acuity are normal, and eye-preference tests indicate left-eye dominance A careful physical examination reveals that in all respects John is decidedly above average in physical development No evidence of glandular disturbances was found Anthropometric measurements furnish evidence of superior physical development and suggest average intelligence and a tendency to put forth but little effort in activities involving volition Right and left grip are decidedly below average In addition to the usual childhood diseases, such as measles, mumps, and chicken pox, John has had an acute attack of appendicitis which has necessitated the removal of his appendix He walked at the age of thirteen months and talked at the age of twenty months He is left-handed, but has been taught to use his right hand for many purposes such as throwing a ball and writing

SCHOOL HISTORY

John entered kindergarten when he was five and one-half years old and, according to school records, he made a very satisfactory adjustment emotionally and socially, but from the beginning had difficulty in learning to read, which, according to his teachers, was explained by his inability to talk plainly In spite of this deficiency he made normal progress until he entered the third grade At this level he failed to be promoted because of spelling and reading dis-

[2] Gates, Arthur I, *The Improvement of Reading* (The Macmillan Company, New York, 1929), pp 388–398

abilities His mother and teachers report a marked tendency toward reversals, and it was at this stage that John acquired a distaste for reading He passed the fourth, fifth, and sixth grades normally, but still showed marked deficiency in reading He has since entered junior high school and his grades for the first year were English "C," mathematics "B," social science "C," general science "C," art "A," physical education "B," and printing "B" However, in spite of these marks, his score on the Sangren-Woody Reading Test, June, 1932, was that of a child two months in the fourth grade, and his only interest in reading was that which dealt with mechanical subjects

INITIAL STATUS IN READING

A survey of the results of reading tests indicates that John is decidedly below standard His average reading grade, determined by certain results of Gray's Oral Reading Paragraphs,[3] the Iota and Word Discrimination tests, and from the composite score on the Sangren-Woody Reading tests is that of a child seven months in the third grade Assuming the expectancy grade to be that of a child five months in the seventh grade, the reading index is 0 49 or, in other words, John is reading only half as well as he should read

TENTATIVE DIAGNOSIS AND SUGGESTIONS FOR REMEDIAL WORK

It is assumed in this case that John is intelligent (Binet I Q 112, Performance I Q 103) and that he has a background of experience which would aid him in the interpretation of printed symbols From a study of the perception tests it is evident that John's ability to perceive geometrical figures and his ability to match these figures is normal, but that his ability to match words with words is decidedly below normal No adequate explanation for this is possible unless it be due to mental set against reading The physician's report of normal visual acuity and the absence of muscular imbalance of eye muscles probably eliminates the physiological factor in the problem Careful observation of John as he reads shows (1) regressive eye movements with nine to twelve fixations per line, (2) marked lip movement and vocalization, (3) a decided inability to attack new

[3] Monroe, Marion, *Children Who Cannot Read* (University of Chicago Press, Chicago, 1932), pp 183–197

words, and (4) no satisfactory method of reading for content An analysis and a classification of errors made on Gray's Oral Reading Paragraphs and the Iota and Word Discrimination tests is shown in Figure 29 A study of those data indicates that the significant errors are those of consonants, refusals, and words aided It is possible in this case that mental set against reading has been established early by some unknown cause, and this attitude has interfered with the development of satisfactory reading habits indicated

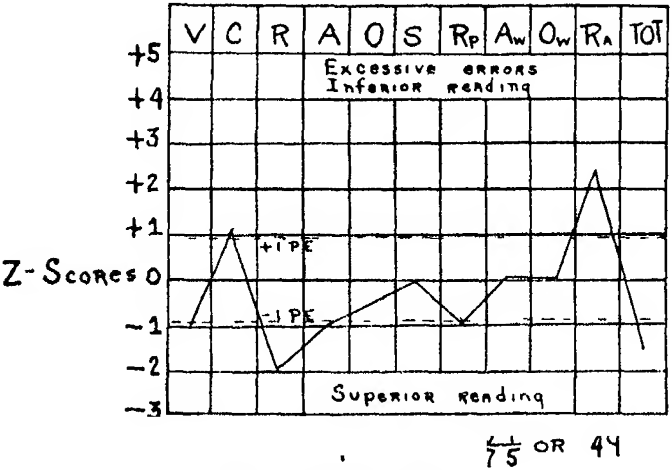

Fig 29 Profile of errors

by vocalization, regressive movement, and excessive fixations These too frequent fixations, due perhaps to inability to recognize and recall certain word patterns, may be caused by poor visual memory Consonant errors may be the result of carelessness and vocalization, but the outward manifestation of inner speech The picture indicates an interaction of four basic conditions (1) no satisfactory method of attacking new words, (2) inadequate reading habits, (3) no adequate method of reading for content, and (4) an unwillingness to master difficult tasks A brief summary of disabilities, their basis of observation, and remedial suggestions are given in Table V

TABLE V

SUMMARY OF DIAGNOSIS

Disability	Basis of observation	Remedial suggestions
Frequent refusals and words aided resulting from inadequate method of word attack	See profile of errors and results of survey tests	Develop method of word analysis by looking at beginning and ending of words and by finding words within words Study words of subject-matter area *
Nine to twelve fixations per line	Actual counting with mirror	Construct and use practice materials similar to that prepared by Pressey †
Frequent consonant errors	See profile of errors	Follow remedial suggestions made by Monroe in *Children Who Cannot Read*, pp 116–126
Vocalization	Observation while reading new material	Ignore for present
No adequate method of reading for content	Analysis of procedure while reading history and geography texts	Develop habit of using following procedure 1 Make preliminary survey 2 Notice carefully the type in which headings are printed 3 Study tables, drawings, and graphs 4 Watch carefully for technical words and master their meaning 5 Find the main thought of each paragraph 6 After preliminary survey and initial reading, recall content by reciting to self 7 Stop after each main section and associate new ideas with data already known

* Pressey, L C, *The Technical Vocabularies of the Public School Subjects* (Public School Publishing Company, Bloomington, Illinois, 1931)

† Pressey, L C, *A Manual of Reading Exercises for Freshmen* (The Ohio State University Press, Columbus, Ohio, 1928)

REMEDIAL TREATMENT AND RESULTS

An attempt was made to develop a method of word analysis by looking at the ending and beginning of words and by finding words within words The student in charge of remedial treatment tried to develop the recognition and meaning of words in certain subject-matter areas such as history and geography The Pressey lists were used for this purpose Later an attempt was made to construct and use materials similar to those prepared by Pressey in *A Manual of Reading Exercises for Freshmen* These exercises were used to focus attention on thought patterns rather than on word configurations Remedial suggestions made by Monroe[4] were used to eliminate consonant errors, and, since vocalization in this case may aid comprehension, it was ignored

After four months of remedial instruction, given four periods each week for twenty minutes, equivalent forms of the Stanford Achievement Reading Tests were administered Significant growth of three years in paragraph reading and of one year and five months in word meaning is indicated The Sangren-Woody Reading Test was not used on a retest because of its recent application in a testing program Later, in September of 1932, a grade score of 6 0 was obtained on the Detroit Silent Reading Test Results of an equivalent form, applied in January of 1934, show a grade score of 7 8, or a gain of 1 8 years It should not be assumed that these tests measure all the factors which make up reading ability or that remedial instruction was responsible for all the apparent gain Maturation, practice effect, and certain emotional factors should also be considered in interpreting this gain The following observations have been made by John's parents and teacher he (1) has a satisfactory method of attacking new words, (2) has acquired the ability to read more satisfactorily for content, (3) has established certain satisfactory reading habits, and (4) according to the number of books taken from libraries, shows an increased interest in reading However, eye fatigue and inability to proceed rhythmically from line to line are reported, and it is quite possible that all the factors in the problem have not been adequately considered

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[4] *Op cit*

THE EXAMINEE DEFINES "SHREWD"

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"SHREWD" appears as the twenty-third word in one of the two fifty-word vocabulary lists of the Stanford Revision of the Binet-Simon Tests According to Lewis M Terman (4), the "vocabulary test was derived by selecting the last word of every sixth column in a dictionary containing approximately 18,000 words, presumably the 18,000 most common words in the language," and the words in this test "are arranged approximately (though not exactly) in the order of their difficulty" In reply to criticisms Professor Terman (5) elaborated on the efficiency of the vocabulary test in an article describing a study of 631 children and 482 adults A high correlation between the results obtained on the vocabulary test and the mental ages for both groups was reported, with slight differences in those of the two sexes Therefore, it is reasonable to assume that the average individual of fourteen years should successfully define twenty-five words in either of the two columns, or fifty words in both, and hence should be able to define correctly the word "shrewd"

The purpose of this paper is to determine, first, whether "shrewd" is properly placed in order of difficulty, and, secondly, whether it is a desirable word to include in a vocabulary list that has, in part, diagnosis of intelligence as its aim

THE POSITION OF "SHREWD" IN A VOCABULARY LIST

In 1918 Professor Terman (5) suggested that there were certain words in the vocabulary test, which, because they are affected by the personal equation, "should ultimately be replaced by others equally difficult but less troublesome to score" Margaret V Cobb (1) discussed the order of difficulty in connection with words of the first part of the vocabulary and concluded that certain words which are more abstract in nature are more difficult, and hence should be rearranged if they are to be placed in the proper order Miss Cobb's work, however, was only with very young children, but she made the suggestion that work of a similar nature might be advantageously done with

other words of the vocabulary list. Selling and Stein (3), in a study reported in 1934, compared one hundred delinquent boys with a control group of nondelinquents, and found that in their scores on the Terman vocabulary list the former revealed an average retardation of one year as compared with the latter group. Whereas Terman (5) had reported a correlation of 0.91, with a probable error of 0.0046, when he correlated the achievement of children on the vocabulary test with their mental ages, Selling and Stein found a correlation of 0.78, with a probable error of 0.025, in the performance of one hundred delinquent boys.

Our present study was made on the basis of data obtained from 983 children and adults examined at the Mental Hygiene Clinic of the Jewish Social Service Bureau of Detroit. Of these, 560 were females and 423, males. These were further divided into diagnostic categories, according to intelligence groupings: 136 superior individuals, of whom 60 were females and 76, males; 423 normal, of whom 244 were females and 179, males; 174 dull normal, of whom 97 were females and 77, males; 134 border-line, of whom 74 were females and 60, males; and 116 feeble-minded, of whom 85 were females and 31, males. The chronological age of the persons examined ranged from 9 years upward.

All examinees were from homes in which English was spoken, and all were born in the United States and had lived here all their lives. All had attended public schools.

J. A. Magni (2) writes that "it is impossible to deny the value of a large vocabulary provided every word stands for a living, clear-cut idea. Otherwise it will be so much mental baggage." With this in mind, let us examine the history and the current meaning of the word which is the subject of our investigation.

The word "shrewd" has a history of varied meanings. *The Century Dictionary and Cyclopedia* reveals that there has been elevation of its sense "from 'cursed' through 'mischievous, cunning' to 'astute, sagacious.'" For a more elaborate history of the word we may refer to the *New English Dictionary*, which is replete with meanings of "shrewd" now obsolete. The word has been defined as "malicious," "mischievous," "wicked," "depraved," "naughty." Animals which have evil dispositions and which are vicious and fierce were considered "shrewd." "Cursed," "poor," and "unsatisfactory" were synonymous with "shrewd." A bad physical condition was a "shrewd" con-

dition Events were called "shrewd" if fraught with evil or if they "had injurious or dangerous consequences" "Shrewd" was used interchangeably with "severe," "harsh," or "sharp" in describing winds or weapons A hard sound was a "shrewd sound" Signs of ill omen or things ominous, persons who were awkward or who scolded were designated by the term "shrewd" [1] From these meanings "shrewd" came to signify "cunning," "artful," "tricky" in the more derogatory sense until it evolved into the meaning of "cunning," "sagacious," "clever," "discriminating," "sharp," or "astute" in the favorable sense (*New English Dictionary*)

Funk and Wagnalls New Standard Dictionary of 1932 defines "shrewd" as "having keen insight, especially in small or worldly matters, characterized by skill at understanding and profiting by circumstances, displaying keen discernment, sharp, sagacious, astute"

Webster's New International Dictionary of 1933 states that "shrewd implies native cleverness, or sharpness of wit or judgment, in practical affairs", and includes "biting," "harsh," and "keen" as correct definitions

The reason for giving the history of the word will be noted later, but for our present purposes the current and hence acceptable definitions, as listed by the several standard dictionaries, are those which have the more favorable sense

To determine whether the word is now in its approximate order of difficulty in the list examinees were selected who were fourteen years or over and who, according to Terman's diagnostic categories (4), were either normal or superior Results are given in Table I

Three hundred and twenty-five individuals of normal or superior intelligence were asked to define "shrewd" Of these, 163, or 50 2 per cent, defined the word properly Of those fourteen years of age, 36 7 per cent passed the word, 30 per cent of the females and 41 4 per cent of the males Of those fifteen years of age, 40 per cent were successful, 43 8 per cent of the females and 36 4 per cent of the males Of those sixteen years of age or over, 56 4 per cent succeeded, 53 8 per cent of the females and 63 4 per cent of the males According to Binet-Simon, between 66 and 75 per cent should be able to pass a

[1] See *The New Century Dictionary of the English Language*, *A New English Dictionary on Historical Principles*, and *An Etymological Dictionary of the English Language* by the Rev Walter W Skeat, and *The Century Dictionary and Cyclopedia*.

TABLE I

PERCENTAGE OF PERSONS CHRONOLOGICALLY FOURTEEN YEARS OF AGE OR OVER AND OF NORMAL OR SUPERIOR INTELLIGENCE WHO SUCCESSFULLY DEFINED "SHREWD"

	Females			Males			Total		
Age in years	No taking test	Passed		No taking test	Passed		No taking test	Passed	
		No	Percentage		No	Percentage		No	Percentage
14	20	6	30 0	29	12	41 4	49	18	36 7
15	32	14	43 8	33	12	36 4	65	26	40 0
16 or over	156	84	53 8	55	35	63 4	211	119	56 4
Total	208	104	50 0	117	59	50 4	325	163	50 2

test at any one chronological age level, in order to establish the validity of the use of the test (4) It would seem, therefore, in view of our findings, that the word "shrewd" is too difficult for children fourteen or fifteen years old, inasmuch as the required percentage of children in these age groups did not pass the test To determine more accurately where "shrewd" might be placed so that it would be in relative order of difficulty, examinees were selected who were fourteen years of age or over and who had superior intelligence Results are given in Table II

Fifty-one persons, or 78 6 per cent of the sixty-five having superior intelligence, succeeded in defining the word This indicates that "shrewd" would be properly placed in the vocabulary list among those words given to superior adults, that is, beyond the thirty-third word in the vocabulary test, instead of being in the twenty-third place, as it is at present

Incidentally, it is interesting to note that in the aggregate there were no important differences shown between the responses of the males and the females

THE ADVISABILITY OF RETAINING "SHREWD" IN THE TEXT

The second part of our paper is intended to determine the advisability of the use of "shrewd" in the vocabulary test. For this pur-

TABLE II

PERCENTAGE OF PERSONS CHRONOLOGICALLY FOURTEEN YEARS OF AGE OR OVER AND OF SUPERIOR INTELLIGENCE WHO SUCCESSFULLY DEFINED "SHREWD"

Age in years	Females			Males			Total		
	No taking test	Passed		No taking test	Passed		No taking test	Passed	
		No	Percentage		No	Percentage		No	Percentage
14	6	3	50.0	11	8	72.7	17	11	64.7
15	4	4	100.0	5	4	80.0	9	8	88.9
16 or over	28	23	82.1	11	9	81.8	39	32	82.1
Total	38	30	78.9	27	21	77.7	65	51	78.6

pose we carefully recorded and classified according to the sex and the intelligence rating of the examinees all the wrong definitions given in the 983 tests. In so doing we soon found that the vast majority of these incorrect definitions were derogatory in character. They related to rules of conduct, social behavior, manners, appearance, mental states, and the like. The list of definitions with derogatory meanings is as follows:

Cross, angry, speak crossly, to snap out of hand, a person with a bad temper, *all worn out, dirty*, shabby, not dressed *very well, sloppy*, rude, impolite, not polite, not courteous, illmannerly, not using courtesy, interrupts, butts in when another talks, discourteous, hurt people's feelings, vulgar, impudent, mean, rough, cruel, not good, bad, throw something at somebody, strict-like, not nice, coarse, not so good, ill way of acting, unkindly, naughty, disobedient, severe, act hard, impossible, not frank, sneaky, not to do right, nervy, smother, throw things around, primitive, doing wrong, jealous, not pleasant, get fresh, awful, bad dress, bashful, not pay attention, obstinate, scared, to keep away, somebody don't want you, shun, cut short, stuck up, snobbish, cool-like, egotistical, timid, backward, stubborn, shy, one who doesn't mind their own business, nosey, queer, withdrawn like, old-fashioned, mad person, odd, wild, untamed, peculiar, not knowing, not up-to-date, irregular, dried-up like, eccentric, funny-looking, forlorn, mad, uncomfortable, ridiculous, tight-fisted, close, did not want, tore up, boasting, stripped, bold, common, ignorant, somebody sues you, to throw away, don't like you, cut all up, one who has been shot.

"Rude," "mean," "impolite," "bad," and "wild" were each used more than any one other incorrect definition. Though these

wrong definitions were derived from persons of all ages, that is, of nine years or older, the vast majority came from those of thirteen years or older

Tables III, IV, and V show the number of cases in each diagnostic category, the number defining the word successfully, the percentage passing, the number who frankly admitted they did not know, the number of responses with derogatory meanings, the number of responses with non-derogatory meanings, the number of incorrect responses, and the ratio of the number of responses with derogatory meanings to the number of wrong responses given, first according to sex and then in total

In the aggregate there seems to be little difference in the proportion of the males and the females passing the test and in the ratio between the responses with derogatory meanings and those incorrect, although there are some wide variations in the several groups, for which we cannot, at present, account For this reason only Table IV, giving the results for all cases, will be discussed

Of the 136 persons of superior intelligence 65, or 47 8 per cent, answered correctly, 32 admitted they did not know, 39 gave wrong responses, of which 31, or 79 5 per cent, carried derogatory meanings Of the 423 individuals of normal intelligence 125, or 29 6 per cent, answered correctly, 132 admitted they did not know, 166 gave incorrect responses, of which 148, or 89 2 per cent, were derogatory Of the 174 persons of dull normal intelligence 23, or 13 2 per cent, defined "shrewd" correctly, 65 stated they did not know its meaning, 86 gave incorrect definitions, of which 71, or 82 6 per cent, were derogatory Of the 134 persons of border-line intelligence 6, or 4 5 per cent, defined the word correctly, 59 did not know the word, 69 gave wrong definitions, of which 58, or 84 1 per cent, were derogatory Of the 116 feeble-minded persons only one successfully defined the word, 77 admitted they did not know, 38 gave incorrect responses, of which 34, or 89 2 per cent, were derogatory Of the total of 983 persons 220, or 22 4 per cent, defined the word correctly, 365 stated they did not know what it meant, 398 gave incorrect definitions Of these 398 responses, 342, or 85 9 per cent, had derogatory meanings

It appears that many of the derogatory meanings are not unlike the obsolete or archaic meanings of the word We shall not, however, discuss the etiological factors involved in the situation, since any such discussion would lead us into the realm of speculation Whatever

TABLE III

RESPONSES BY FEMALE EXAMINEES DEFINING 'SHREWD' CLASSIFIED BY DIAGNOSTIC CATEGORIES

N = did not know W = wrong D = derogatory

Diagnostic group	No taking test	Passed		No N	No D	No Non D	No W	Ratio D W
		No	Percentage					
Superior	60	34	56 667	10	13	3	16	81 250
Normal	244	79	32 377	67	87	11	98	88 776
Dull normal	97	13	13 402	33	39	12	51	76 471
Border line	74	3	4 054	34	35	2	37	94 595
Feeble-minded	85	0	0 000	55	29	1	30	96 667
Total	560	129	23 036	199	203	29	232	87 500

TABLE IV

RESPONSES BY MALE EXAMINEES DEFINING "SHREWD," CLASSIFIED BY DIAGNOSTIC CATEGORIES

Diagnostic group	No taking test	Passed		No N	No D	No Non D	No W	Ratio D W
		No	Percentage					
Superior	76	31	40 789	22	18	5	23	78 261
Normal	179	46	25 698	65	61	7	68	89 706
Dull normal	77	10	12 987	32	32	3	35	91 429
Border line	80	4	5 000	25	23	9	32	71 875
Feeble-minded	31	1	3 226	22	5	3	8	62 500
Total	423	91	21 513	166	139	27	166	83 735

TABLE V

RESPONSES OF ALL EXAMINEES DEFINING "SHREWD," CLASSIFIED BY DIAGNOSTIC CATEGORIES

Diagnostic group	No taking test	Passed		No N	No D	No Non D	No W	Ratio D W
		No	Percentage					
Superior	136	65	47 794	32	31	8	39	79 487
Normal	423	125	29 551	132	148	18	166	89 157
Dull normal	174	23	13 218	65	71	15	86	82 558
Border-line	134	6	4 478	59	58	11	69	84 058
Feeble-minded	116	1	862	77	34	4	38	89 211
Total	983	220	22 380	365	342	56	398	85 930

the cause, it seems from the varied responses given that there is at present confusion as to the meaning of the word

CONCLUSION

From the data given we may draw the following conclusions

1 The word "shrewd" is placed at a level in the vocabulary list that is too difficult for the average fourteen- or fifteen-year-old child It should be transposed, if used at all, to the level commensurate with the words listed for the superior adult

2 Because of the evolution of the term "shrewd" in the English language, its meaning is rather vague to a great many people of normal or superior intelligence In order to have a valuable word for a vocabulary test, one conveying "a living clear-cut idea," as expressed by Magni (2), it appears that a term less equivocal should be substituted for this one

3 On the basis of these conclusions we may well advance another, that other words in the vocabulary list should be restandardized on the ground not only that there may have been insufficient standardization at the time the words were placed in the list, but also that as time goes on words take on newer meanings and drop older ones During the period of transition from older conceptions to newer they are unfit for clear-cut definition

4 We also suggest that the method of selecting words at random for a vocabulary list for the purpose of determining levels of intelligence will not be so valuable as a method which would include the study of each word in relation to its history and popular conception in the several geographical divisions and sociological groupings of the country Those words which reveal a more stable history and convey a more uniform idea throughout the several sociological strata will probably be more efficient in describing intelligence and have a more lasting value in a vocabulary test

MENTAL HYGIENE CLINIC
JEWISH SOCIAL SERVICE BUREAU
DETROIT, MICHIGAN

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WILLIAM — A BEHAVIOR PROBLEM

THEODORE S HENRY

WILLIAM came to our notice in the summer of 1932 through a letter from the principal of one of the larger high schools in southwestern Michigan The result of this correspondence was a visit to us by the father, which in turn was followed by a conference with both parents and by a clinical examination of the subject Through these conferences and the correspondence with William's high school principal we accumulated a rather lengthy bill of particulars, all revolving around an attitude of general irresponsibility

William was reported to have no sense of obligation to do the work asked of him by his teachers or to perform the duties laid upon him by his parents He was greatly given to rationalization and was exceedingly fruitful in excuses for his failures He maintained an attitude of insincerity At times he was a source of trouble in the classroom, engaging in vexatious and mischievous pranks and disturbing those around him This had also been manifested to such an extent in the Sunday school which he attended that the pastor of the church had called upon William's parents with the request that they no longer allow him to attend

Although greatly annoying, none of these things would seem to be of very grave consequence, but all in all, in company with William's extremely poor work in high school, they were sufficient to cause his father to decide that conditions must be corrected What was really the exciting cause for this, however, was the discovery that William had been engaged in the practice of stealing and selling golf balls, obtained by breaking into lockers belonging to different members of his father's golf club, all of which the boy stoutly denied and continued to deny for a time, even after faced with incontrovertible evidence of his guilt

In brief summation, the case when brought to us presented the following elements calling for correction (1) flagrant disobedience of parents, (2) almost complete lack of any definite sense of responsibility, (3) an overbearing attitude and a tendency to attract

attention to himself through undesirable means, (4) failure in school work, and (5) petty theft, involving breaking and entering

William was born on May 29, 1917, and his chronological age when first we saw him was fifteen years and three months At that time he had nominally completed the sophomore year of high school, although with a very poor record, and was to be classed as a junior at the beginning of the next school year Physically, he presented the appearance of a boy normal for his age He is reported to have been very good-looking as a child and to have attracted the attention and interest of all those with whom he came in contact His present appearance is pleasing, and his manners are good The father reports that as a child William was tongue-tied, and he still shows a slight tendency to lisp Except for a marked case of hay fever, his present health is very satisfactory

Up to the time when he came to us William had always attended the same school system He entered kindergarten when he was four and one-half years old, was allowed to skip grade 1B, and never failed of promotion in the grades His attendance has always been regular, and he has rarely expressed dislike for any of his teachers Reports from former teachers show that he has always made high scores on intelligence tests, and that when he became interested, he did work of a high level of excellence

So far as home conditions are concerned all the facts which we have been able to gather point to a family of culture William's parents are both graduates from one of the larger universities of the "Big Ten" At the time of their first contact with us the father was 38 years old, the mother was two years older. The father is a traveling salesman, who spends much of his time on the road, although not so much as formerly He is very exacting and has expected much of William William has a tendency to "work" his mother, who is much less firm than the father and, in the latter's absence, is likely to be indulgent Both parents are fond of society and have had rather keen social desires William has a sister six years younger than he There are no other members of the family

In our regular routine of tests of intelligence and personality traits the Stanford Binet gave an I Q of 112, with no "scattering" In the Pintner-Patterson Short Performance Scale his mean score was at the eightieth percentile for his chronological age Responses to the Kent-Rosanoff Free Association Test showed a rather high

individualistic tendency, but not abnormally so. An application of the Bernreuter Personality Inventory yielded results leading us to infer very good emotional balance, a high measure of self-sufficiency, marked extraversion, and a very strong tendency to dominate other individuals in face-to-face situations.

In our attempt to set up a background from which William's undesirable traits might possibly have emerged we have been led to the consideration of several environmental circumstances which might have had some undesirable influence. When William was about four years of age he one day built up a pile of boxes and loose pieces of boards in the back yard and then went away, leaving it standing. Later, while no one was watching, a younger sister managed in some way to pull this pile down upon herself, receiving injuries which caused her death. For a long time after this William's parents upbraided him for his carelessness and its tragic outcome, and it was often held up to him as a lesson against his careless ways. It is needless to say that such a set of circumstances might have a most unfortunate effect upon the developing mental life of a young child, and on through the years of boyhood.

His mother's indulgence as compared with his father's sterner attitude might also be mentioned. While the father was away from home the boy was under the gentler discipline of his mother. When he returned, sterner measures were in order, but not consistently so. Sometimes the father apparently would feel that he had been a little too severe with the boy and would show him considerable leniency. To counteract this, very probably when the next need for discipline arose, remembering his previous leniency, he would go somewhat beyond the bounds of reasonable severity.

Early in his school career, because of his attractive appearance and pleasing ways, William was given much favorable attention by his teachers, and this may have built up in him a somewhat excessive desire to attract attention, while giving him an excellent opportunity to practice that characteristic. There are facts also which readily point us to the supposition that the boy, early in life, was able to get about what he wanted from his teachers and parents, and indeed has had little opportunity to develop a sense of responsibility and even little need for doing so.

Another circumstance which seemed to us to be of some possible importance is that his younger sister is an out-and-out conformist,

always receiving good marks in school and never giving her teachers or parents trouble of any sort During his later years she has all too often been held up to him as a model, and he has had to listen to far too many pointed comparisons between her excellence and his general worthlessness

Although our study of this case revealed many such interesting and suggestive facts, it must be admitted that our findings, including the results of the intelligence and personality tests, were far from being adequate for the formation of a satisfactory diagnosis They did lead us, however, to certain tentative conclusions, which, conjectural as they were, made up what might be called our preliminary diagnosis, which we state as follows

1 Lack of obedience may be due to acquired habits of response and a desire to attract attention by being contrary

2 Lack of responsibility may be due to his feeling that he can still accomplish his purpose with the least possible expenditure of effort

3 His stealing may be due to (*a*) financial stress and strain of adolescent boy with interest in a girl, (*b*) his previously mentioned lack of responsibility, and (*c*) the adventure of the undertaking

Remedial indications were no more definite or adequate than our diagnosis had been However, because of the nature of the situation, it seemed to us that a change of environment was at least worth trying Accordingly, at the opening of the school year in September, 1932, we succeeded in getting him enrolled in the high school conducted by Western State Teachers College, thus securing the further advantage of having him under our continued observation In addition, a most excellent boarding home was found for him in a family in which there were no children or any other boarders or roomers Here he was treated practically as a member of the family in a well-kept and cultured home, in the best of social surroundings His problems were explained to the people with whom he was to stay, and they showed a most kindly and intelligent interest in him and gave us most efficient coöperation They did not allow him to take any undesirable advantages, and he was given to understand that he would be expected to discharge his personal responsibilities in a satisfactory manner Because of the poor record which William brought from his former school special permission had to be obtained for his admission to our high school This, in turn, required that we in a general way acquaint the high school principal with the salient features of the case

William soon made a very good adjustment to all phases of his new environment. He took interest in the class work and the social life of his new school, and got on very well in the home in which he lived. He created no disturbance in the school at all, was well spoken of by his teachers, carried a full scholastic load, and did better than average work in the subjects which he carried. At mid-term he had a mark of "C +" in each of his studies, and while, of course, this was not a high scholastic record, it was much better than he had achieved in his home high school the previous year.

William's improvement continued until near the close of the twelve-week school term, when a series of entirely unlooked-for events occurred. In spite of careful investigation we had found no indications of accentuation of sex. However, toward the close of the school term it was discovered that letters of a highly pornographic nature were passing between William and some of his boy friends in his home town. To this we did not attach any great importance, thinking it perhaps only a passing phase, not at all exceptional among boys of that age, and perhaps chiefly a boyish way of attempting to show off. Incidentally, from these letters we also received information to the effect that William, with a gang to which he had belonged, had during the previous summer practiced shoplifting activities in a number of stores in a larger city near by. Shortly after the discovery of the letters the man of the house where William was staying, having noticed that he left at a rather late hour almost every evening on a mysterious errand, one evening followed him at a distance and discovered that he was engaged in going through the lawns of the neighborhood from house to house and peeping in at the windows.

The next outbreak of activity of this nature occurred only a short time later, when William, in company with another high school boy, was found in the basement of the women's gymnasium, apparently seeking opportunity to gain a view of the shower room through a peep hole of some sort. His excuse on this occasion was that he was looking for an ax, but when pressed as to his need for an ax, or his reason for thinking that an ax might be found in that part of the building, he remained silent, or gave only confused replies. As a result of this the father of the other boy made a vigorous protest against William's continued presence in the school. He was allowed to stay until the end of the term, finishing his work with a better

than "C" average, but was denied admission thereafter Whatever may have been the advisability of this action, it was taken without our having any part in it, and thus direct contact with the case was lost It might be worth mentioning that, during the time we were concerned over this escapade, William was examined by a psychiatrist working under the Couzen's Foundation in another city and was reported to present no problems worth mentioning

Since his return to his home William has been subjected to a rather strict regimen instituted and carried out by his father, from whom we have received for our files two lengthy reports setting forth his methods and his estimates of results obtained Because these reports present so clear a picture of the later stages of this history, I shall quote freely from them

The first of the reports was written after the close of the school year, in June, 1933 After leaving our high school, just before Christmas, William had waited at home until the opening of the second semester of his home high school This letter from his father covers that part of the school year

Until we arrived home nothing was said about our knowing of his unsatisfactory conduct at your school or of the "gang" activities here with which he had been, and even then indirectly was, associated The letters that had come into our hands were then handed to Bill one by one This was followed by our telling him that we knew of all the things that had been going on at Kalamazoo and that because of them the authorities there would not permit him to re-enter that school I told him that under no condition was he to associate with members of the clique that had been disclosed by their correspondence The result of this disclosure and [these] instructions was that this "gang" seems to have completely broken

You will recall that from the confiscated correspondence we learned of some light-fingered work that had been done in by this group of boys The Saturday afternoon before Christmas he and I drew all of his savings from the local bank and drove to There we went to store after store, told the manager just what had taken place some months before, and Bill with his own money paid for every article that he could remember had been taken This was done regardless of whether or not he actually did the taking, for as he explained, he was equally guilty even though in some instances he was merely with the others Since this there has been no further trouble of this kind although money and other valuables have been freely left about the house

When school started January 23rd, I made a requirement of Bill that if I were at home, he could not go to bed a single night until he passed my examinations If I were away, all lessons missed in each subject were to be passed to my satisfaction that week-end in all four subjects Starting with the very first school day he came home completely unprepared in all subjects The first night we were up till after midnight, the second night till after two, the third

night until after three But each time he answered all questions to my satisfaction before he was permitted to retire Of course the thought was that he would soon decide that this was a poor way to do and that then he would take advantage of every minute he had in school to become thoroughly prepared so that we could go through each subject in fifteen or twenty minutes, giving him at least a part of the evening for recreation and a chance to get to bed at a reasonable hour Instead of his reasoning in that way though, he apparently was of the opinion that I would weaken and that in a short time he would again have an opportunity to slide along and follow the line of least resistance Thus the enforcement of my requirement very soon became an endurance contest Through the latter part of January, all of February and March, and for about the first half of April there was no effort on his part to do any real studying in school nor to snap into his work when he came home During that period of nearly three months, there probably were not more than one or two nights when he completed his work so as to be in bed before one o'clock There were many nights when we were up until three and four o'clock, some five o'clock, and one night when he was in bed only about an hour

Enough of this letter has been quoted, I think, to indicate clearly the nature of the discipline to which William was subjected during the semester in question In a word, he was held rigidly to a satisfactory performance of his school activities, including class recitations, notebook work, reports, papers, outside readings, and supplementary work of every sort The same procedure was carried out in all cases of infraction of school citizenship, of which only two or three occurred Here he was compelled to assume complete responsibility and to make whatever restitution was asked of him Privileges were allowed him only upon condition of satisfactory work During the first few weeks of the semester his school marks were not at all satisfactory, but showed such improvement later that at the end of the semester he received a mark of "B" in each of his academic subjects — English, trigonometry, government, and commercial law — and lost the distinction of being on the honor roll only because of a "C" in physical education He received a class citizenship mark in each class of "2," and his advisory citizenship mark was "1," indicating the highest degree of excellence

Later developments are shown by the following quotations from a second report made to us at the close of the first semester of the present school year

You will find attached Bill's weekly school record for the first semester of this year There is also enclosed a clipping taken from the local paper showing that his work for the first half-year placed him on the 'A–B' honor roll Bill has secured these results with comparatively little attention on my part His mother has followed his work in French somewhat closely but not in a manner that would be in any way comparable with our experience of one year ago

During this semester, according to the father's report, there was very little misconduct at school of any major importance, and William's conduct outside of school was entirely satisfactory There was, however, still some trouble in getting him to follow instructions readily His final marks for the semester's work were algebra, "A", English, "B", chemistry, "B –", French, "B –", hygiene, "B", with a general citizenship mark slightly better than "2"

By way of summary, we might ask of ourselves two questions (1) What improvement has been made? (2) To what is the improvement due?

In answer to the first of these we may say that improvement is indicated in the following ways

1 There has been no further instance of theft

2 There has been no repetition of any undesirable symptoms in the field of sex

3 There has been a most desirable change in the nature of his associates

4 There has been a marked change for the better in his conduct at school and at home

5 There has been a great improvement in his scholastic record as revealed by school marks

To answer the question why these changes have taken place is a more difficult task Some might say at once that they are most probably due only to the maturation factor, operating especially in the emotional field in such a way as to overcome the disturbances of a passing phase At best, our answers cannot escape being highly conjectural However, let us list our calculations

1 We cannot attribute these changes to any set remedial formula, for we have not been able to discover one which might apply

2 Neither have we made any attempt to use the methods of psychoanalysis

3 In spite of its rather spectacular termination, we still think that our short-lived experiment in environmental change was not a complete failure

4 The breaking up of the gang to which William formerly belonged and the substitution of more desirable associates seem to have been wise measures

5 William's parents appear to be taking a greater and a more intelligent interest in him than ever before

6 If required to be categorical, we might say that the chief factor has been the rigid discipline imposed upon him by his father This really has amounted to a process of conditioning or of reëducation, by means of which it would appear that habits and attitudes of irresponsibility are gradually giving way to more desirable patterns

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A CASE OF SPONTANEOUS DIABETES IN THE DOG

EPHRAIM B BOLDYREFF

PANCREATIC diabetes rarely occurs in dogs In the case observed the animal was about eight months old when the symptoms were first noted, it remained under observation several months Later on it went through two terms of pregnancy, giving birth to three puppies, one of which showed skeletal deformities suggestive of hydrocephaly and another of which died shortly after birth

The dog was well built and manifested no outward signs of serious disease Its eyesight was deficient, however According to Sveringhaus (5), visual errors become marked at about the same time that the other evidences of diabetes appear

The manifestations of diabetes – polyphagia, polydipsia, and polyuria — were pronounced The polyphagia was transitory and alternated with periods of loss of appetite during which large quantities of water were imbibed Diarrhea and vomiting were also present Although the diabetes was mild, a remarkable constancy was noted in the persistence of hyperglycemia, glucosuria (at times reaching 10 grams of sugar excretion in 24 hours), and leukocytosis A slight diminution of the blood coagulability was also noticed (1) (See Table I)

The animal was operated on, and a fistula of the stomach was established The gastric contents showed the presence of blood and, occasionally, numerous motile bacteria, on staining, Gram-negative bacilli and Gram-positive cocci were found This suggests deficient secretion of gastric juice or hypochylia Because of digestive disorders insufficiency of pancreatic secretory function was suspected, and it seemed probable that some pancreatic disorder such as pancreatitis was present Cecil (2) emphasizes the occurrence of chronic pancreatitis in diabetes mellitus Joslin (3) also considers pancreatitis a possible factor in the etiology of diabetes

TABLE I

HYPERGLYCEMIA, GLUCOSURIA AND LEUKOCYTOSIS IN SPONTANEOUS DIABETES IN THE DOG

A female dog (about eight months old on November 17, 1925)

Date	Body weight	Glycemia	Glucosuria	Leukocytosis	Blood coagulability
	Grams	Percentage	Percentage	Per c mm	Time in seconds
11/17/25	10500	0 400	0 630	14000	50
11/25/25		0 240		14400	70
12/ 2/25	11000		0 440		
1/11/26	12420	0 130		15400	120

The increase of weight is due to growth, and the decrease of blood sugar may be attributed to treatment Frequent determinations of the number of leukocytes were made, and on only one occasion was a normal figure obtained (8,000), in the majority of tests a certain degree of leukocytosis was present All determinations were made in the fasting condition, about twenty hours after the last feeding

An accidental exposure to cold resulted in pneumonia, which proved fatal It is well known that diabetics are very susceptible to infection (4) Post-mortem examination showed congestion of the lungs, and also revealed the presence of pancreatitis This finding was confirmed by microscopic examination The gland showed pronounced congestion, atrophy of parenchyma, necrotic areas, hyaline degeneration of the acini, and stasis of pancreatic ducts No pathological changes were detected in the islands of Langerhans The photomicrograph demonstrates some of the pathological changes (Pl XCVI) The pathological findings already mentioned were corroborated by the late Dr A S Warthin, of the University of Michigan (Report 4167-LAI)

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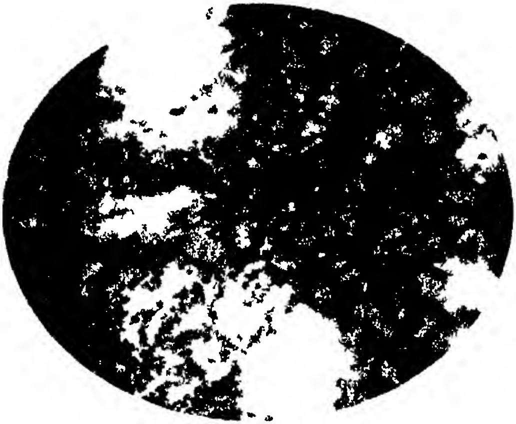
BATTLE CREEK SANITARIUM
BATTLE CREEK, MICHIGAN

PLATE XCVI



Pancreas of a diabetic dog showing necrotic areas in the secretory cells and normal island of Langerhans. Formalin fixation. Mayer's stain. Magnification × 280.

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THEORETICAL CONSIDERATIONS CONCERNING THE ACIDITY OF CERTAIN AREAS OF THE BRAIN DURING THE ADMINISTRATION OF LOW OXYGEN *

HUGO KRUEGER

1 INTRODUCTION

IN A previous paper from this laboratory (Gesell and others, 1932) data were presented which could be interpreted as indicating that the tissues in general may turn alkaline during the administration of low oxygen of suitable concentration It was pointed out, however, that the interpretation that all cells of the body turned alkaline was somewhat questionable

Since no direct evidence concerning the acidity of the brain was obtained in those experiments, it is the purpose of this paper to present indirect evidence that certain areas of the brain may have turned acid The underlying principle is that lactic acid will form in those regions of the brain not receiving oxygen and will diffuse toward the capillaries Since not all the necessary data are available and since many of the available data are not sufficiently quantitative, only a rough approximation can be made Further, the usable data must be taken from experiments on many different animals Significant errors may arise on this account The fact that neurones are not exact geometrical figures offers another difficulty However, first approximations may indicate the state of affairs or suggest possibilities which can be tested experimentally

2 DATA

In this attempt to supply indirect evidence concerning the acidity of certain regions of the brain the following data will be assumed to be essentially correct

* Paper from the Department of Physiology, University of Michigan, Ann Arbor, Michigan

1 The average diffusion constants of oxygen and lactic acid are assumed as approximately the same for brain and for muscle The diffusion constant for oxygen is $1\,64 \times 10^{-5}$ c c per sq cm per minute under a diffusion gradient of one atmosphere per cm (Krogh, 1918) From the data of Eggleton, Eggleton, and Hill (1928) the average diffusion constant for lactic acid is $2\,8 \times 10^{-5}$ grams per sq cm per minute under a diffusion gradient of one gram per cm

2 The brain is richly supplied with capillaries Under the optimum condition it may be considered that each capillary forms the center of a cylinder which it supplies with oxygen Craigie (1926) gives the total length of the capillaries in a cube, 100 μ on edge, of fresh brain from the male albino rat Taking the length of the capillaries as the length of the cylinder, the radius of the cylinder containing the necessary volume may easily be computed (See Table I, columns 1 and 2)

TABLE I

CAPILLARY SUPPLY AND THEORETICAL OXYGEN REQUIREMENTS OF SOME REGIONS OF THE BRAIN

	Total length of capillaries in 0 001 c mm	Average radius of tissue supplied by capillary	Minimum oxygen pressure for adequate oxygen supply
Nucl dors mot X	517 μ	24 8 μ	50 mm Hg
Nucl fascic solit	630 μ	22 5 μ	39 mm Hg
Form retic later	645 μ	22 2 μ	37 mm Hg
Form retic med	674 μ	21 7 μ	35 mm Hg

3 During the administration of 7 24, 6 09, and 5 69 per cent of oxygen the partial pressure of oxygen in the expired air dropped to 36, 30, and 28 mm Hg (Gesell and others, 1932) In the alveolar air the pressures were probably around 30, 25, and 23 mm Certainly the average oxygen pressures in the brain capillaries were not above these values In these experiments during the administration of low oxygen blood lactic acid increased 0 15, 0 38, and 0 60 mg per c c, respectively The excess carbon dioxide lost by overventilation above that accounted for by oxidations amounted to 7 93, 11 93, and 12 25 volumes per cent when calculated on the basis of the whole animal

4 The oxygen consumption of intact whole brain (dog) is reported as 0 1 c c per gram per minute This figure may be unsatisfactory, but according to Winterstein (1929) it represents the best efforts to date Brain is approximately 45 per cent gray matter and 55 per cent white matter (Mathews, 1930) The metabolism of the white matter is probably similar to that of peripheral nerve Regarding this as 0 005 c c per gram per minute, the metabolism of the gray matter becomes 0 216 c c per gram per minute

5 Since the transformations (Meyerhof, 1925) carbohydrate → lactic acid → sodium lactate involve about 300 calories per gram of lactic acid and since one liter of oxygen supplies 4800 calories at an R Q of 0 81, an oxygen debt of 1 c c should be accompanied by the production of 16 mg of lactic acid (It is conceivable that other anaërobic processes may occur and lower this figure considerably) Sixteen mg of lactic acid is the chemical equivalent of 4 c c of carbon dioxide Thus, in the absence of oxygen, acid is produced at a rate four times that during oxidative metabolism

It is assumed that the energy obtained by the brain from 1 c c of oxygen may be replaced by the production of 16 mg of lactic acid The validity of this assumption may be seen by comparing the rates of oxidation for *excised* brain as found by Warburg and Lobel (see Winterstein, 1929) with the rate of formation of lactic acid in the *excised* brain obtained by McGinty and Gesell (1925) and Haldi (1932) According to Warburg the rate of oxygen consumption for excised brain was 0 03 c c per gram per minute, and according to Lobel, 0 02 c c per gram per minute The average of the curves of McGinty and Gesell and of Haldi indicates that in the excised brain during the first 30 seconds the rate of lactic acid formation is 0 40 mg per gram per minute Dividing by 16 (16 mg of lactic acid = 1 c c of oxygen) we find that this corresponds to oxidations at the rate of 0 025 c c per gram per minute

Similarly, Haldi (1932) has found that directly after excision lactic acid forms in muscle at a rate of 0 06 mg per gram per minute Dividing this by the usually accepted figure of 0 005 c c per gram per minute for the oxygen consumption (Verzár, 1912) we obtain a relationship of 12 mg of lactic acid to 1 c c of oxygen Considering the variable sources of the data, the agreement with the theoretically expected ratio of 16 to 1 is satisfactory (If 385 calories instead of

300 calories is considered the thermal equivalent of 1 gram of lactic acid, the theoretical ratio would be 12 5 to 1)

3 THE OXYGEN PRESSURE REQUIREMENT OF THE BRAIN

If one knows the rate of oxygen consumption and the length of capillaries in a given region of tissue, one can calculate the minimum pressure of oxygen in the capillaries necessary to supply the region with oxygen The necessary equations for this computation have been developed and presented previously (Hill, 1928, Krueger, 1932) The equation for determining the minimum pressure of oxygen necessary to supply a given region of tissue is

$$(1) \qquad y + \frac{a}{4K}(r_1^2 - r_c^2) - \frac{ar_1^2}{2K} \log_e \frac{r_1}{r_c} = 0,$$

where y_o is the oxygen pressure in the capillaries, a is the oxygen consumption, K the diffusion constant of oxygen, r_c the radius of the capillary, and r_1 the radius of the cross-section of tissue supplied by the capillary (This equation is number 18 in the previous paper by the author)

With this equation the minimum pressure of oxygen necessary to supply the hypothetical brain cylinders of Table I was computed, a capillary diameter of 6 μ (r_o = 3 μ) was assumed The values obtained are given in Table I, column 3

If similar capillary and metabolic relationships hold for the rat and the dog, these figures are very interesting, since a similar figure is obtained by an entirely independent method For simplicity the blood is assumed as loaded with oxygen under a partial pressure of carbon dioxide of 40 mm Hg and unloaded at a partial pressure of 60 mm The venous oxygen pressure corresponding to a given arterial oxygen pressure is then read from curves modified from those of Bohr (1904) relating Hb saturation to oxygen and carbon dioxide pressures The mean oxygen pressure surrounding the brain cells must almost be that of the venous blood leaving the brain Winterstein (1929) states that the oxygen consumption of the brain is 0 1 c c per gram per minute and the volume flow of blood 1 4 c c per gram per minute Consequently, blood on passing through the brain loses 7 09 volumes per cent of oxygen According to Bohr's (1904) curves dog's blood that has lost 7 09 volumes per cent of oxygen from 20 volumes per

cent at complete saturation has an oxygen pressure of 42 mm. This agrees well with the postulated figures of 35–50 mm. calculated for the cylinders.

Since these figures represent an ideal distribution of capillaries, the actual pressure would perhaps be somewhat lower. Thus the cells of this area of the brain, and perhaps of most other areas as well, may be laboring near the lower border of stability, where slight changes in the oxygen pressure of the milieu will introduce a change in the type of metabolism. The higher pressures might even suggest that some areas of the brain continually use an acid metabolism to supply some portion of their energy.

4. THE FRACTION OF BRAIN TISSUE SUFFERING FROM OXYGEN WANT DURING THE ADMINISTRATION OF LOW OXYGEN

Considering 50 mm. the minimum oxygen pressure for unimpaired oxidative metabolism for a cylinder of brain tissue of 24.8 μ

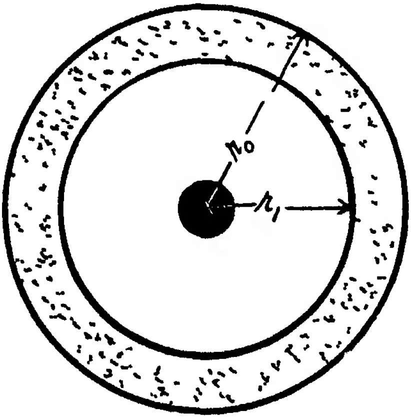

FIG. 30. Cross-section of region drained by a capillary. The solid area is a capillary of radius r. The radius of the region drained by the capillary and ordinarily supplied with oxygen by the capillary is r_0. The radius of the region supplied when the oxygen pressure is reduced is r_1. Lactic acid will form and accumulate in the region between r_0 and r_1 (stippled), and will diffuse toward the capillary.

radius supplied by a 6 μ capillary from the center, the computed radii of the fractions of the tissue receiving oxygen, when the oxygen pressures are only 30, 25, and 23 mm. Hg, are 20.5 μ, 19.1 μ, and 18.6 μ, respectively. The fractions of the total volume not receiving oxygen are 0.31, 0.41, and 0.44, respectively (see Fig. 30).

5 THE THEORETICAL CONCENTRATION OF LACTIC ACID IN CERTAIN AREAS OF THE BRAIN WHEN RECEIVING INSUFFICIENT OXYGEN

If a deficit in oxidations of 1 c c is accompanied by the formation of 16 mg of lactic acid, lactic acid will form and accumulate in the area from $r = 24\ 8\ \mu$ to $r = 20\ 5\ \mu$ during the administration of 7 24 per cent oxygen It will diffuse from this region across the areas from $r = 20\ 5\ \mu$ to $r = 3\ \mu$ into the capillaries The concentration of lactic acid will progressively increase from $r = 3\ \mu$ to $r = 24\ 8\ \mu$ When a steady state is reached the amount of lactic acid diffusing into the capillaries per unit length will be $\pi \times 0\ 00248 \times 0\ 00248 \times 16 \times 0\ 216 \times 0\ 31$ mg per minute when the oxygen pressure is 30 mm Hg

The quantity diffusing into the capillaries per unit length in unit time may also be expressed by

$$T = \frac{2\pi k(w_1 - w_2)}{log_e r_2 - log_e r_1}, \tag{2}$$

where T is the amount of lactic acid diffusing into the capillaries per minute per unit length, w_1 is the concentration at the internal radius r_1, and w_2 is the concentration at the external radius r_2 (see equation 22, Krueger, 1932)

For the specific instance under consideration k is the diffusion constant of lactic acid, whereas $w_2 - w_1$ gives the concentration difference of lactic acid that must be maintained between r_2 and r_1 in order to insure the desired rate of diffusion The values of r_2 and r_1 are 20 5 μ and 3 μ, respectively Since the total quantity diffusing in unit time through a unit length is given in the preceding paragraph, all the necessary data are available to calculate the concentration difference, $w_2 - w_1$ The result obtained is 0 23 mg per gram Hence during the administration of 7 24 per cent oxygen the theoretical concentration of lactic acid at $r = 20\ 5\ \mu$ was 0 23 mg above that in the blood stream, and since blood lactic acid increased 0 15 mg per c c the concentration at $r = 20\ 5\ \mu$ increased to a value 0 38 mg per gram higher than that obtaining before the administration of low oxygen The increase in lactic acid in the region from $r = 20\ 5\ \mu$ to $r = 24\ 8\ \mu$ would be slightly greater than 0 38 mg

Further, owing to the hyperventilation induced by the low oxygen, 7 93 volumes per cent of nonoxidative carbon dioxide (equivalent

to 32 mg of lactic acid) were eliminated Since the removal of n moles of carbon dioxide from a buffer system at a pH of 7 5 or less and the simultaneous addition of $n + h$ (where n and h are any positive numbers) moles of lactic acid result in an increased concentration of hydrogen ions, the calculations indicate that the region from $r = 20\ 4\ \mu$ to $r = 24\ 8\ \mu$ turned acid during the administration of 7 24 per cent oxygen

Similar calculations may be made for the experiments during which 6 09 and 5 69 per cent oxygen were administered The values of T are $\pi \times 0\ 00248 \times 0\ 00248 \times 16 \times 0\ 216 \times 0\ 41$ or 0 44 The value r_1 is 3 μ in both cases, while r_2 has the values 19 1 μ and 18 6 μ The concentration differences are found to be 0 29 and 0 31 mg per gram The increases in blood lactic acid were 0 38 and 0 60 mg per gram Hence the theoretical increase in lactic acid was 0 67 and 0 91 mg per gram for some regions of the brain The nonoxidative carbon dioxide lost was 11 93 and 12 25 volumes per cent (equivalent to 45 and 49 mg of lactic acid)

Thus during the administration of 7 24, 6 09, and 5 69 per cent oxygen 31, 41, and 44 per cent, respectively, and perhaps more, of some regions of the brain become acid A more exact evaluation of the oxygen pressure in the brain and a consideration of the superbasal metabolism of the respiratory neurones doing increased work would make the acid effect in the region under consideration still greater In other regions with a larger capillary supply the acid effect would be much less In regions where the capillary supply is sufficient to provide oxygen to all areas an alkaline effect may even develop Under these conditions lactic acid might leave the blood and enter the brain, as was indicated by the experiments of McGinty (1929), in which only slight impairment of brain metabolism was induced

Similar calculations for muscle from the data given by Martin, Woolley, and Miller (1932) indicate that the oxygen pressure is positive throughout the muscle even during the breathing of 5 69 per cent oxygen Since lactic acid forms in muscle and passes into the blood stream under some resting conditions, it is suggested either that a high positive pressure of oxygen is necessary to prevent lactic acid accumulation in muscle or that the limiting factors in determining whether oxidations are sufficient to balance the anaërobic metabolism are enzymatic Calculations based on direct observation

of the lactic acid increase and carbon dioxide loss indicate that the muscle sometimes turned alkaline and sometimes acid during the administration of low oxygen (Gesell and others, 1932)

6 BRAIN ACIDITY DURING LOW OXYGEN AS RELATED TO SIZE OF CELLS

Since computations involving the brain tissue cylinders indicated that some regions of the brain became acid during the administration of low oxygen, an attempt was made to determine the hypothetical conditions within spherical neurones regarded as metabolic units with a constant pressure of oxygen presented at the surface This case is not so easily handled as the last because it involves an estimation of the actual rate of oxygen consumption within the neurone No direct determinations are available Indirect estimations are difficult because of the lack of anatomical data Also the relative rates of metabolism of structures found in the gray matter are not known Presumably the dendrites may have as high a rate of metabolism as the cell bodies of the neurones or even a higher one The neuroglia may have a metabolism similar to that of connective tissue If the neuroglia has a secretory function, its metabolic rate will be much higher

Similar directional conclusions will be reached whether one considers that the metabolism is primarily a function of the cell bodies or that the other structures in the gray matter also have a significant metabolism In the first case there would be an oxygen pressure at the surface of the neurones approximately equivalent to the venous oxygen pressure In the second case the oxygen pressure at the surface of the cells would be much lower, since a significant gradient would develop, owing to the oxygen consumption of the other structures This second case reduces in the ideal state to that of the cylinder previously discussed If we consider, however, that the oxygen consumption is primarily a function of the cell body, the treatment as spherical cells would be more exact

If oxygen does not penetrate the entire cell,

$$y - y_0 \quad 6K \quad \quad 3K\ r \quad r_0$$

where y is the pressure of oxygen at any distance from the center of

the cell, r_o is the radius of the cell, and r_1 the radius at which inward diffusion of oxygen ceases

The concentration of lactic acid will be given by

$$(4)\quad w = w_1 - \frac{b}{6k}(r^2 - r_1^2) \quad \text{from } r = 0 \text{ to } r = r_1,$$

$$(5)\quad w = \frac{w_1 - w_o}{r_o - r_1}\,\frac{r_1 r_o}{r} + w_1 - \frac{w_1 - w_o}{r_o - r_1}\,r_o \quad \text{from } r = r_1 \text{ to } r = r_o,$$

$$(6)\quad \frac{dw}{dr} = \frac{w_o - w_1}{r_o - r_1}\,\frac{r_1 r_o}{r_1} \quad \text{at } r = r_1, \text{ and}$$

$$(7)\quad R = 4\pi k\,\frac{w_1 - w_o}{r_o - r_1}\,r_1 r_o,$$

where w, w_1, and w_o are the concentrations of lactic acid at r, r_1, and r_o, respectively and where b is the rate of formation of lactic acid, k the diffusion constant of lactic acid, and R the quantity of lactic acid formed by the cell per minute The average concentration throughout the cell will be given by

During the administration of 7 24 per cent oxygen 8 volumes per cent of carbon dioxide have been drained off the tissues If the acidity is to remain constant, 32 mg of lactic acid per 100 grams must accumulate Since blood lactic acid increased 15 mg per 100 c c, an accumulation of only 17 mg above the concentration in the blood stream would indicate a reaction in the tissue more acid than the basal reaction

Assuming that the cell volume is one sixth of the total volume of the gray matter (in many places the cell volume is less than one sixth) the minimum diameter of a cell has been computed such that the average increase in lactic acid thoughout the cell is 0 32 mg per gram above the basal level The diameter of the cell was calculated to be 59 μ

7 DISCUSSION

The application of these deductions to the control of ventilation is complicated by the fact that the chemical control of ventilation

cannot be limited to the central nervous system alone, since Heymans (1931) has demonstrated that the respiration may be modified by chemical stimulation of the carotid sinus and afferent vagus endings But granting stimulation and inhibition of pulmonary ventilation from arterial injection of acid and base distal to the carotid gland (Heymans, 1931, Owen and Gesell, 1931) and stimulation as well as depression from similar injections of sodium cyanide and sodium sulphide (Winder, Owen, and Gesell, 1932), it is tentatively concluded that the *acid metabolism of the brain during oxygen want* may be a significant factor in determining the degree of pulmonary ventilation The conclusions of Schmidt (1932) that "the respiratory center is directly affected by alteration in blood supply in the manner stipulated by the hypothesis of Gesell" and that "the sensitivity of the cells of the center to changes in CO_2 tension or pH of arterial blood is vastly greater than that of the sinus reflex mechanism to any chemical changes in the blood" support this view A final estimation, however, must await accumulation of more accurate data regarding oxygen consumption, oxygen pressure, diffusion rates, anatomical relationships, and the relative importance of peripheral and central chemical control of ventilation

The computations indicate that concentrations of materials undergoing metabolic transformations vary from point to point in the tissues Hence in trying to deduce the fundamental laws controlling distribution of materials between the blood and tissues the concept of the steady state rather than of a dynamic equilibrium must be borne in mind A priori one would expect the tissues to show a higher or lower concentration than the arterial blood, as the venous concentration is higher or lower than the arterial concentration The concentration differences between the tissues and the blood may be expected to be high or low, depending directly upon the rate of metabolism and inversely upon the diffusion constant of the material under consideration

For the specific case of carbon dioxide pressure differences of approximately one millimeter of Hg above the venous pressure are theoretically sufficient to insure complete diffusion

8 SUMMARY

During the administration of low oxygen sufficient carbon dioxide is removed from the body to indicate that the tissues in general

may turn alkaline A consideration of some of the principal factors involved suggests, however, that certain areas of the brain may become acid

An analysis of the evidence from various authors indicates that the energy liberated by the formation of lactic acid under anaërobic conditions in muscle and brain immediately after excision is the thermal equivalent of the energy derived from oxidations in excised strips For this reason it is assumed that the development of an oxygen debt of one c c in muscle or brain is accompanied by the formation of 16 mg of lactic acid

A consideration of the rate of diffusion of oxygen, the rate of consumption of oxygen, and the capillary supply of the dorsal vagal nucleus, as established by Craigie, indicates that during the administration of 7 24 per cent oxygen approximately 30 per cent of the tissue of this nucleus will not receive oxygen Lactic acid will form and accumulate in the portions of the brain not receiving oxygen A further increase in the general level of brain lactic acid should develop from the increased concentration of lactic acid found in the blood The calculated net increase in lactic acid in the fraction of the dorsal vagal nucleus unsupplied with oxygen will more than balance the loss in carbon dioxide due to the increased ventilation, and the end result will be an increase in the acidity of this fraction Considered from the standpoint of individual cells, those whose diameter is approximately 60 μ or greater will become acid

Hence the calculations indicate that certain areas or cells of the brain assumed to contribute to the control of respiration become acid during the administration of low oxygen It is concluded that the altered acid metabolism of nerve cells may be a significant factor in the regulation of respiration The significance of these conclusions is considered in regard to the regulation of ventilation

It is pointed out that in many distribution studies a steady state rather than equilibrium conditions maintains

This application of the diffusion equations to experimental data presented by Gesell, Krueger, Nicholson, Brassfield, and Pelecovich is tentative and is given primarily to indicate a possible indirect method of attack of certain physiological problems

The author wishes to thank Dr R Gesell of the Department of Physiology and Dr V C Poor of the Department of Mathematics for their friendly advice

University of Michigan

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FURTHER ADDITIONS TO THE LIST OF ARANEAE FROM MICHIGAN

ARTHUR M. CHICKERING

IN AN effort to obtain as nearly complete information as possible concerning the spider fauna of the state of Michigan I have been collecting these animals during the past six years. Up to the present time about two hundred and sixteen species have been listed (Chickering, 1932, 1933, 1934). This paper gives sixty-three additional species, thus bringing to about two hundred and eighty the total number recorded for the state as a result of my studies. A few specimens appear to represent new species, and these have been laid aside for careful study and detailed description.

In connection with my recent work I am glad to acknowledge the cooperation and generosity of the following araneologists: Mr. W. J. Gertsch, of the American Museum of Natural History, who has examined and placed all my Thomisidae collected during the past year; Professor R. V. Chamberlin, of the University of Utah, who has studied my whole collection of Lycosidae made prior to 1933; Mr. Wilton Ivie, who has aided Professor Chamberlin in the identification of my Lycosidae and who has also identified miscellaneous specimens belonging to other families; and Mr. Nathan Banks, of the Museum of Comparative Zoology, Harvard University, who has helped me with numerous identifications and who has most generously presented me with many valuable reprints.

It has been customary to publish notes in connection with my lists of Michigan spiders. In this paper, however, as in the preceding one, no notes accompany the collecting records, owing to the necessity for strict economy in printing costs.

SUB-ORDER ARACHNOMORPHAE

AMAUROBIIDAE

AMAUROBIUS FEROX (Walckenaer). — Albion, September, 1933; January, 1934.

Agelenidae

Cicurina arcuata Keyserling — Albion, October, 1932, January, 1933

Cicurina pallida Keyserling — Albion, April, 1933

Cicurina sp (?) — Homer, April, Albion, May, 1933

Cybaeota calcarata (Emerton) — Marquette, July, 1932

Pisauridae

Dolomedes scriptus Hentz — Probably Albion, summer, 1933 ?

Dolomedes tenebrosus Hentz — Mosherville, Hillsdale Co, July, Wolf Lake, Jackson Co, July, 1933

Dolomedes triton triton Walckenaer — Douglas Lake, Cheboygan Co, July, 1933

Lycosidae

Allopecosa kochii (Keyserling) — Douglas Lake, Cheboygan Co, August, 1931

Lycosa avara (Keyserling) — Pine Lake, Eaton Co, September, 1933

Lycosa punctulata Hentz — Pine Lake, Eaton Co, September, 1933

Lycosa riparia Hentz — Ann Arbor, June, 1916, Pine Lake, Eaton Co, July, 1930

Lycosa sp (?) — Probably a new species. Albion, September, 1933

Pardosa fuscula Thorell. — Ishpeming, May, 1931

Pardosa groenlandica (Thorell) — Albion, June, 1932

Pardosa modica brunnea Emerton. — Albion, May, 1933

Pirata maculata Emerton — Douglas Lake, June, 1930, Albion, August, 1931

Pirata sylvestris Emerton — Albion, June, 1930, August, 1931, Douglas Lake, July, 1930

Schizocosa bilineata Emerton — Douglas Lake, July, 1930, Albion, May, June, 1933

Dictynidae

Dictyna frondea Emerton — Marquette, July, 1932

Theridiidae

Crustulina sticta (Cambridge)

Robertus fuscus (Emerton) — Marquette, July, 1932

Theridion globosum Hentz — Albion, July, 1933

Linyphiidae

Bathyphantes brevis (Emerton) — Marquette, July, 1932
Ceraticelus atriceps (Cambridge) — Negaunee, July, 1932
Ceratinella brunnea Emerton — Gladstone, August, 1932
Ceratinella placida Banks — Marquette, July, 1932
Cornicularia directa (Cambridge) — Albion, October, 1932
Cornicularia pallida Emerton — Marquette, July, 1932
Eperigone maculata Banks — Big Bay, Marquette, July, Negaunee, August, 1932
Hypselistes florens Cambridge — Munising, Marquette, July, 1932 Many localities in the Southern Peninsula
Microneta cornupalpis (Cambridge) — Marquette, July, 1932
Microneta olivacea Emerton — Marquette, July, 1932
Microneta persoluta (Cambridge) — Sands, Marquette Co, July, 1932
Microneta viaria (Blackwall) Grand Marais, Marquette, July, Negaunee, July, August, 1932
Oedothorax montanus (Emerton) — Marquette, July, Negaunee, August, 1932
Tmeticus debilis (Banks) — Marquette, July, 1932

Argiopidae

Araneus corticarius (Emerton) — Mosherville, Hillsdale Co, October, 1933
Cercidia prominens (Westring) Marquette, July, 1932
Glyptocranium bisaccatum (Emerton) — Albion, July, 1933

Mimetidae

Ero furcata (Villers) - Marshall, October, 1932
Mimetus interfector Hentz — Quincy, July, 1933

Drassidae

Cesonia bilineata (Hentz) — Wolf Lake, Jackson Co, July, Albion, August, 1933

Thomisidae

Ebo latithorax Keyserling — Albion, May, 1933, January, 1934
Misumenops oblongus (Keyserling) — Albion, June, Mosherville, Hillsdale Co, July, 1933

PHILODROMUS EXILIS Banks — Charlotte, June, Wolf Lake, Jackson Co, July, 1933

PHILODROMUS INFUSCATUS Keyserling — Albion, August, 1933

PHILODROMUS LENTIGINOSUS Keyserling — Albion, September, October, 1933

PHILODROMUS MARXI Keyserling — Wolf Lake, Jackson Co, July, 1933

PHILODROMUS EMERTONI Bryant — Concord, June, 1933

PHILODROMUS SATULLUS (MINUTUS) Banks — Formerly reported from egg sac, adults are now in my collection Albion, May, 1933

TMARUS ANGULATUS (Walckenaer) — Albion, October, 1932, Homer, April, Mosherville, Hillsdale Co, September, October, 1933

XYSTICUS FRATERNUS Banks — Albion, August, 1932, May, 1933

XYSTICUS SP (?) — Albion, June, 1932

CLUBIONIDAE

ANYPHAENA CELER (Hentz) — Albion, November, December, 1933, January, 1934

ANYPHAENA GRACILIS (Hentz) — Albion, May, 1933

ANYPHAENA PECTOROSA L Koch — Mosherville, Hillsdale Co, July, 1933

ANYPHAENA RUBRA Emerton — Wolf Lake, Jackson Co, July, 1933

CLUBIONA SP (?) — Albion, December, 1933

MICARIA MONTANA Emerton — Albion, May, 1933

MICARIA SP (?) — Albion, May, 1933

ATTIDAE

ICIUS SP (?) — Soon to be described as a new species Marquette, July, 1932

PHIDIPPUS ELECTUS Koch — Ishpeming, Sands, Marquette, July, 1932

ALBION COLLEGE
ALBION, MICHIGAN

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NOTES ON THE SPERMATOGENESIS OF SPIDERS

ARTHUR M CHICKERING AND WALTER HARD

ALTHOUGH spiders have never been popular animals in which to study spermatogenesis, several investigators have worked with them in attempts to elucidate the problems of chromosome behavior and the process of spermiogenesis It seems probable that the "nucleolus" described in spiders by Wagner (1896), nearly forty years ago, was a sex chromosome, In a series of three papers dealing with *Agelena naevia* Wallace (1900, 1905, 1909) arrived at the following conclusions after a number of corrections There are two accessory chromosomes in each spermatogonium, in early spermatocytes the two fuse into a single body The bipartite accessory chromosome passes undivided into only half of the secondary spermatocytes It then divides in the second maturation division, so that half of the spermatids possess an accessory chromosome and half do not The haploid number of chromosomes is about twenty-five Many spermatids show a delayed separation An extracellular axial filament grows out from a centrosome and acquires a small bleb at the center and another at its tip The spermatid nucleus is transformed into a crescent-shaped head of the spermatozoön, and this slips out of the cytoplasm and becomes the mature sperm bearing a tail, as described by Wagner in 1896 Apparently the only worker to locate an XY-pair of chromosomes was Montgomery (1905) in his study of *Lycosa insopita* (*L gulosa* Walck) Bösenberg's (1904, 1905) study of *Lycosa* and a few other forms appears to have been the most thorough piece of work thus far done on the spermiogenesis of spiders Except in minor details his work agrees well with that of Wallace, as this was finally left in 1909 Berry (1906), working on *Epeira sclopetaria* (*Araneus sericatus* Clerck), identified a bipartite accessory chromosome and described its behavior essentially as Wallace did in *Agelena* Painter (1914) studied several species of spiders He found but fifteen chromosomes in spermatids of *Agelena*,

but he agreed essentially with Wallace in regard to the bipartite X-chromosome. Two small ctetosomes were found in each spermatogonium. In the last spermatogonial division these ctetosomes lag and pass into but one of the two cells, which become primary spermatocytes. Thus the latter are of two types, those which have ctetosomes and those which do not. When present these bodies fuse with the accessory chromosome in the rest period and remain thus through the first maturation division and then pass undivided into only one of the two secondary spermatocytes resulting from this division. They appear to divide with the accessory chromosome in the second division, and thus only one fourth of the spermatids would contain ctetosomes. Painter postulated a correlation between the occurrence of two varieties of males in *Maevia vittata* and the peculiar distribution of these bodies. Bodies called "planosomes" by Painter were found to arise in the rest period. They probably fuse with the accessory chromosome in this period and later separate from it during the growth period. They may divide in the first maturation division, but they often lag and behave irregularly. They do not divide in the second division, and they seem to have a very irregular and fortuitous distribution to the spermatids. One of the few recent authors, Warren (1926, 1928, 1930, 1931), has published several papers in this field in which he has dealt with spermiogenesis, with particular emphasis on an unusual method of producing spermatozoa by division of the spermatids. On the basis of this work he has concluded, apparently, that it is difficult if not impossible to retain a belief in the universal application or general significance of the current conception of specific chromosomes bearing linearly arranged genes transmitted from generation to generation. Because of the theoretical importance of his claims and because of the very unusual conditions noted by him we have paid special attention to comparable stages in the animals which we have studied. In certain species this author has represented amitosis as occurring with considerable frequency. In these species the wall of the testis is described as being lined with germinal nuclei which undergo a series of amitotic divisions and thus produce lobules which may be either large-celled or small-celled, depending upon the mode of formation. Cells arising from these divisions can be termed, respectively, spermatogonia, primary spermatocytes, secondary spermatocytes, and spermatids. In certain forms like *Evarcha* the large-celled lobules function as

nurse lobules, while the small-celled lobules produce the spermatozoa Karyokinesis was observed in these animals, but it seemed to be irregular Warren was unable to determine whether the spermatozoa arose by typical karyokinesis or not From the spermatids the spermatozoa are formed in a variety of ways in the different species In some instances he thinks the sperm may be formed, as described by other investigators, from spermatids with a chromatin cap which condenses into the main part of the spermatozoon In the most interesting instances the spermatids within lobules fuse and form a kind of syncytium, after which each nucleus elongates into a "spermatic cord" Then each cord splits longitudinally into two or more threads, each of which condenses into a spermatozoon The splitting may be into fairly equal or very unequal portions, and this is a point greatly stressed by Warren in his criticism of current genetical theory The threads which result from unequal splitting of the cords appear to form quite as functional sperm as do those formed from equal parts King (1925) recently published a brief report on a species of *Amaurobius* studied in Professor Gatenby's laboratory in Dublin He found structures somewhat like those described by Warren, his conclusion is that there is no evidence of amitosis anywhere in the process, but, on the contrary, clear evidence that the process continues in general as described for the great majority of animals A sex chromosome is clearly evident Both large and small spermatids occur The large ones give rise to normal sperm while the small ones, with little cytoplasm, are regarded as degenerate

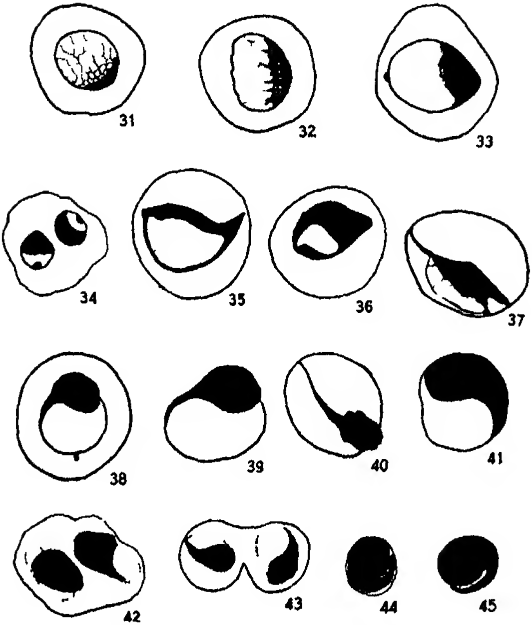
Our own studies have been started in the hope of removing some of the inconsistencies and contradictions now so prominent in the literature and also in the hope of adding considerably to the knowledge of the occurrence and the behavior of the cytoplasmic components of the sex cells in these animals Little is now known about chondriosomes and Golgi bodies in these animals, and it seems likely that a study of these would contribute much to our knowledge of the architecture of the sperm During the spring and summer of 1933 several males of *Schizocosa bilineata* (Emerton), two species of *Lycosa*, and a species of *Pardosa* were collected and their testes prepared for study in several different ways All the testes studied in the preparation of this paper were killed in Bouin's fluid and stained in iron haematoxylin The material has proved to be fairly good for the study of chromatin but, of course, is practically

worthless for a study of cytoplasmic constituents. In reality, only a sort of general survey has been accomplished thus far. We hope in the near future to continue the work with a much more intensive study of both the chromosomes and the cytoplasmic components.

We have found no indications of amitosis in any part of the testes of our animals. Mitoses occur in all the stages in which they are expected, and we have no doubt that this is the regular method of cell multiplication, as in most other animals. To be sure, we have found many difficulties in making exact determinations of the number of chromosomes in the various stages and also in the study of other important features of spermatogenesis, but we see no evidence of amitotic irregularities.

Spermatogonia appear to be scarce in all our material. We have found a few cells in which counting of chromosomes is possible but difficult. Prochromosomes occur in the anaphase of the last spermatogonial division in *Lycosa* and possibly in *Schizocosa* and *Pardosa*. The cells containing the prochromosomes were confined wholly to the periphery of the testis in *Lycosa*. The prochromosomes appear to spin out into leptotene threads, which then pair in quite typical fashion and sometimes are more or less polarized. The threads become considerably intertwined in this and succeeding stages and strongly suggest Janssen's famed chiasmata (1924). Later the double threads condense to form prominent tetrads, which tend to become V-shaped and U-shaped. A large bipartite body may be found in all stages from the leptotene stage to the first metaphase. This is regarded as the sex chromosome, but its subsequent history has not been followed through to the spermatids with any degree of certainty. It seems probable, however, that the Lycosidae studied by us are of the so-called XO-type in respect to their sex chromosomes. Many counts have been made of the chromosomes during metaphases of both divisions, and we have determined the approximate number present. But the results are not yet consistent, and we hesitate to make a definite statement which may need to be changed later, as in several other instances. The inconsistencies may be due to bodies similar to or identical with Painter's planosomes, which are difficult to distinguish from ordinary chromosomes.

The general pattern of spermiogenesis seems to be essentially the same in all species thus far studied by us. We have found no evidence of such a division of spermatids as Warren has described. In no case



Figs 31–45 Diagrams to illustrate spermiogenesis in *Lycosa*, *Pardosa*, and *Schizocosa*

Figs 31–32 Spermatids of *Schizocosa*, showing condensation of the chromatin and the origin of the nuclear vesicle

Figs 33–36 Spermatids of *Lycosa*, showing a similar condensation of the chromatin and the development of the nuclear vesicle Figure 34 shows two small spermatid nuclei differentiating within a single secondary spermatocyte

Fig 37 A spermatid of *Pardosa*, showing the disappearance of the nuclear vesicle during the condensation of the nucleus

Figs 38–39 Two later stages in the differentiation of the spermatids of *Schizocosa* Figure 39 shows the condensed nucleus at the periphery of the cell, with *no* nuclear vesicle visible

Fig 40 A young spermatozoön of *Pardosa* lying on the periphery of the spermatid cytoplasm

Figs 41–43 Stages in the further development of the spermatozoa in *Lycosa* Figures 42 43 show delayed cytokinesis of secondary spermatocytes

Figs 44–45 Nearly mature spermatozoa of *Schizocosa* and *Pardosa*, respectively In Figure 44 the thin envelope of cytoplasm is shown

have we noted a fusion of spermatids to form a syncytium In all our animals the spermatids are formed in nearly typical fashion and then transform directly into spermatozoa In *Lycosa*, however, cytokinesis of the secondary spermatocyte is often either delayed or omitted altogether, with the result that two spermatid nuclei may be held within a single cytoplasmic mass (Figs 34, 42–43) and apparently differentiate into fully developed sperm still contained within the undivided mass of cytoplasm In typical spermatids a vesicular nucleus is formed which soon localizes its chromatin on one side (Figs 31 33) In many cells at this stage a small body strongly resembling a centriole appears opposite the place of chromatin concentration (Figs 32 33) Concentration of the chromatin continues until we have such an appearance as is illustrated in Figures 37 and 38 We interpret the conspicuous vesicle accompanying the developing sperm as a nuclear vacuole remaining after the chromatin has condensed into a very compact mass Soon the young sperm is elongated, somewhat twisted into a loose spiral, and lies more or less wrapped around the surface of the vesicle (Figs 35–38, 42–43) Soon after this stage the nucleus, together with a thin envelope of cytoplasm, seems to slip out of the old mass of cytoplasm (Figs 39–41) After lying on the surface of the cytoplasm for a time (Figs 39–41) the more or less mature spermatozoa come to lie loose among the old remains of the spermatids (Figs 43–45) Just what happens to the vesicle is uncertain, but it disappears during the separation of the sperm from its surrounding cytoplasm This process should become much more thoroughly understood as soon as some attention can be given to material killed and stained to show cytoplasmic constituents in these cells

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THE MOOSE (*ALCES AMERICANUS*) AND THE WATER SHREW (*SOREX PALUSTRIS HYDROBODISTES*), RARE MAMMALS OF THE SOUTHERN PENINSULA OF MICHIGAN *

CHARLES W. CREASER

RECENTLY we compiled a list of the vertebrates (other than birds) of the region of the University of Michigan Biological Station. With this unpublished list is a discussion of the zoogeography of the vertebrates of this region, many of these reach the limits of their range at or near this station. Two mammal records, however, are of special importance since they constitute the only specimen records for the Southern Peninsula of Michigan.

While upon general consideration there can be little doubt that at an early date the moose was to be found over much of the Southern Peninsula of Michigan, no specimen material is on record. Wood (2) cites a record listed as from Presque Isle County, which has been amplified by Wood and Dice (3) and which reads as follows: "John Rodger in October, 1883, saw a fine male near Black Lake." This paper contains records from three counties, as follows: "Charles C. McDonald, a lighthouse keeper, saw a moose in this county [Huron] about 1870 and heard of others later," "A. B. Covert at one time had the antlers of a male killed in August, 1881, in Union Township [Messaukee]," "C. K. Dodge saw the body of one brought to Port Huron, which had been killed in the winter of 1864 in Sanilac County." These constitute our records from the Southern Peninsula, no specimen material is included.

During the summer of 1933 a party of biologists from the University of Michigan Biological Station, under the direction of Dr. Frank C. Gates, discovered at Sleeping Bear Point (Leelanau County)

* Contribution from the Biological Station of the University of Michigan and from Wayne University

two teeth and a fragment of the maxilla of a moose These remains certainly were covered with sand before the coming of the white man Dr Gates's description of the location and some indication of the age of the burial are as follows

> The teeth were on the eroded side of the Sleeping Bear dune Disturbances have resulted in the complete loss of vegetation on this side and the blowing away of the sand at a considerable rate per year The depth of sand removal from the time that I first knew the dune (1911) to where these teeth were found, I would say was about twenty feet

Two of the fragments consisting of a tooth and the right upper premolar two still contained in a part of the maxilla have been donated by the collector, David Gates, to the United States National Museum and the Museum of Zoölogy, University of Michigan, Ann Arbor, Michigan

The water shrew, *Sorex palustris hydrobodistes* Jackson, has been taken rarely in the Northern Peninsula of Michigan (1) An adult male was caught by R A Stirton in Cheboygan County in the gorge at the edge of a cold trout stream on the University Biological Station property It is now in the Museum of the University of Michigan (No 58807) and is the only record south of the Straits of Mackinac The identification was made by Dr Jackson

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THE GRAYLING IN MICHIGAN*

CHARLES W CREASER
Wayne University
AND
EDWIN P CREASER

I INTRODUCTION

FEW of our fishes have commanded as much interest as the magnificent grayling It is regarded by many as the most beautiful of our game fishes, and the mystery of its disappearance is intriguing Once the most abundant fish in many of our northern streams, it has now been reduced in numbers to a few individuals, which survive in the Otter River in Houghton County

Under pressure from fishermen and naturalists generally the State Department of Conservation of Michigan has tried to culture and replant the deserted waters with this highly prized fish, but without success This may in part be attributed to deficiency in our knowledge of its life history

Recently a few specimens from the Otter and Au Sable rivers in Michigan and some of the very closely related Montana grayling have come into our hands for study through the courtesy of the Cranbrook Institute of Science and the Museum of Zoology of the University of Michigan We are thus able to make a study which is concerned with the growth of the grayling in the Otter River as determined from the scales We hope that it will stimulate further study of the grayling It is to be desired greatly that at least enough of these unique fishes may be raised to save the species from extinction, even if numbers sufficient for sport fishing be impractical or inadvisable to maintain

II FORMER DISTRIBUTION OF GRAYLING IN MICHIGAN

The rivers, lakes, and bays mentioned by Michael (1905, p 24) as formerly inhabited by grayling include the following Muskegon,

* This study was made possible by the writers' connection with the following institutions Wayne University, the Cranbrook Institute of Science, and the University of Michigan (the Museum of Zoölogy and the Biological Station)

Manistee, Jordan, Cheboygan, Rifle, and Au Sable rivers, Pine and Portage lakes, Great and Little Traverse bays and Thunder Bay Milner (1874, p 731) says that the grayling occurs in Pine Lake, in the upper tributaries of the Muskegon and Manistee rivers, and in the Boardman, Jordan, Au Sable, Rifle, Marquette, and Au Gres rivers Mershon (1923, pp 142–181) in his *Recollections of My Fifty Years' Hunting and Fishing* states that brook trout were unknown in the Southern Peninsula except in a few streams flowing directly into Lake Michigan in the extreme northern part The grayling, according to the same writer, occurred rather generally throughout the areas in the Southern Peninsula where brook trout are now found Mershon took grayling in the Black River as late as 1903 The first specimen of grayling from the Otter River is recorded by Jordan and Evermann (1896, p 518)

III GRAYLING PLANTS IN THE OTTER RIVER

It is unfortunate, at least for any taxonomic study of the grayling, that an effort was made to plant the closely related Montana grayling in the Otter River The first mention made of plantings of these fishes in this river is in the *Twenty-first Biennial Report of the Michigan Fish Commission* Under the record of grayling plants the following entry is found (p 212) "Houghton County, Otter river, 25,000" These plantings were fry obtained by hatching eggs of the Montana grayling Whether or not they were successful cannot be determined In view of the survival of the species up to the present day in the Otter River it seems necessary to assume at least that conditions may have been favorable for plantings and that some of the fry may have survived

IV PREVIOUS STUDIES OF THE OTTER RIVER GRAYLING

During the year 1922 the grayling were the object of a mostly unpublished study of considerable scope by John N Lowe In the *Biennial Report of the Department of Conservation for 1925 and 1926*, (p 126) he estimates that there were in 1925 between 600 and 700 individuals in the river About 125 of these were removed to the lower part of the state and were planted on the Gladwin game refuge in an old beaver pond, which is now a cat-tail marsh Quite naturally these transplantings seem to have been entirely unsuccessful

V SPECIFIC STATUS OF THE OTTER RIVER GRAYLING

If the 1914 planting of grayling in the Otter was successful, the present race may possibly, but not probably, be hybrid in origin Experts are much puzzled in their effort to separate the various isolated groups of grayling This species appears to have been a relict of the Great Ice Age and to have persisted in favorable cold water sites and has been separated from the circumpolar grayling since that time Quite probably there is no specific difference between the currently recognized three species of North American grayling Our study shows a marked difference in growth rate, but since in each instance there are sufficient data from only one locality, environmental differences cannot be ruled out It is also possible, but not likely, that the Otter River grayling is racially different from the one formerly occurring throughout the northern section of the Southern Peninsula For the present purposes the name *Thymallus tricolor* Cope, 1865, may be used in connection with the Otter River specimens, with the reservations noted above Studies are now in progress by other workers on the specific status of the existing Michigan grayling

VI AGE AND GROWTH STUDIES OF GRAYLING FROM MICHIGAN AND MONTANA

The specimens of grayling at our disposal consist of individuals from Michigan and Montana Specimens from Montana are included in this account to give some idea of the comparative growths

The scales used in this study were obtained from the side of the fish above the lateral line and below the middle of the dorsal fin They were cleaned and mounted in the sodium silicate, glycerin medium Readings and calculations of the age and growth of the grayling were made from a typical fish-scale projector (for methods see Creaser, 1926, pp 10–12)

The scale of the grayling is exceptionally easy to decipher The growth-cessation marks are quickly established and are clearly marked Since the grayling spawn early in the spring, activity at this time merely serves to accentuate the winter mark

Our material of the Michigan grayling consists of thirteen specimens, and all except one are from the Otter River Very fortunately this Otter River series varies in size from 90 mm (4⅝ inches) to 242 mm (11¼ inches) and permits the construction of a tentative

growth curve of specimens from this river All year groups from 0 to III are represented, and to this information we have added computations of length based on scale measurements The scale of the grayling shows conclusively that it undergoes a very definite period of growth cessation, as will be noted in Plate XCVII Computations and measurements show that the average growth of the Otter River grayling for the first growing season is about 86 mm standard length, or about 4½ inches total length At the end of the second growing season they have attained a size of 178 mm, or about 8¼ inches At the end of the third growing season they have attained a standard length of 232 mm, or a total length of about 10¼ inches The growth increment in the fourth growing season cannot be given with any degree of surety We have examined a single specimen preserved at the end of its fourth growing season This specimen, now in the Cranbrook Institute of Science, was removed from the Otter River at the beginning of its third growing season and placed in a hatchery stream At or near the end of its fourth growing season it was 212 mm long, or 11¼ inches total length (see Fig 46)

The single specimen that we have seen from the Au Sable River at Grayling, Michigan, at the end of its third growing season (Sept 1, 1900) was 258 mm long standard length, or 11½ inches total length The computed length for the first growing season is 86 mm., or about 4½ inches, and for the second growing season 191 mm., or about 8¾ inches

The Montana grayling from Georgetown and Rodgers lakes, according to our computations, measurements, and scale readings of seven specimens grow considerably faster than the Michigan grayling from the Otter River The computed length for the first growing season is 91 mm, or about 4¾ inches total length, for the second growing season, 234 mm, or about 10¾ inches (about as long as the average of the Michigan grayling from Otter River one year older) At the middle of the third growing season the Montana grayling averaged 292 mm, or about 13¾ inches total length Two specimens from Rodgers Lake collected in the middle of their fifth growing season averaged 341 mm standard length, or about 15½ inches total length (see Fig 46)

Such data as are available to us indicate that there is little if any difference in growth which may be attributed to sex

From our evidence it seems certain that the grayling in the Otter

River mature at the end of their second growing season The single female specimen of about this age (caught late in the second growing season) which we have from this river shows the eggs in early stages of development, whereas a specimen from Montana of slightly

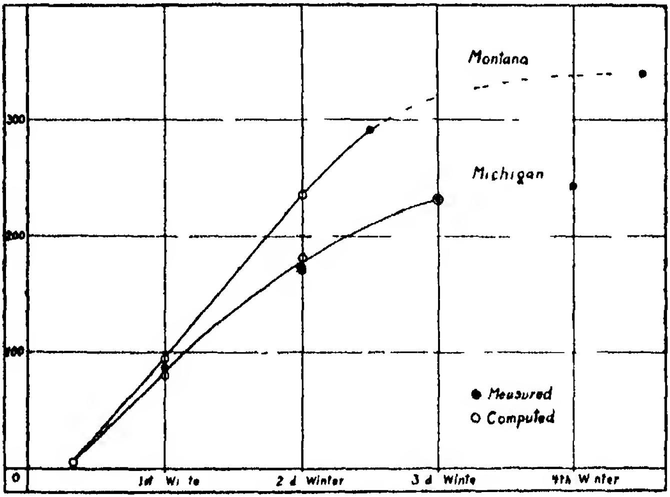

FIG 46 Comparative growths of the Montana and the Michigan grayling For the Montana grayling the unbroken line represents individuals from Georgetown Lake, the broken line, two from Rodgers Lake These last two were not used in the computations For the Michigan grayling the unbroken line represents individuals from the Otter River the broken line, a single specimen from the Otter River, which was removed to a hatchery at the beginning of its third growing season This specimen was not used in the computations

younger age has ripening ova Spawning probably takes place at the beginning of the third season The males are almost mature late in the second growing season The Otter River grayling thus reach maturity at an average size of 178 mm , or about 8½ inches

The comparative growths of the brook trout, the rainbow trout, and the grayling are of interest Ricker (1932, pp 77-81) states that in the Mad River, Ontario, the brook trout late in the summer have an average length in their first growing season of 2 inches, in their second growing season they are 4 9 inches long, in the third growing

season they are 7 6 inches long, and those which are in their fourth season are 10 4 inches long Hazzard (1932, pp 347 349) gives the following information about the average lengths of wild brook trout in New York The average standard length at the end of the first growing season is 9 4 cm ($4\frac{1}{2}$ inches total length), at the end of the second growing season, 13 5 cm (about 6 inches total length), at the end of the third growing season, 16 8 cm (about $7\frac{3}{4}$ inches total length) The brook trout quite clearly is a more slowly growing fish than the grayling

Mottley (1932, pp 148 151) gives some data on the Kamloops rainbow trout (*Salmo kamloops* Jordan) He found a different growth rate correlated with environment of lakes and streams The stream rainbow trout grew more slowly, but even they had attained a length of about 7 inches at the end of the first growing season, 14 inches at the end of the second, 16 inches at the end of the third, 19 inches at the end of the fourth Leach (1923, pp 34–35) states that rainbow trout (*Salmo shasta*) under artificial conditions attain the following lengths at the end of the first growing season, 8–10 inches, at the end of the second, 12 14 inches, at the end of the third 16–18 inches Leach surmises that the trout would average 2 inches smaller under natural conditions The rainbow trout seemingly grow faster than the Otter River grayling

VII NATURAL HISTORY NOTES

The Michigan grayling was formerly a very prolific species Probably the closest approach to its numbers in the state today is that of the smelt, *Osmerus mordax* Like the smelt, the grayling is a spring breeder During the breeding season in the past century thousands of grayling were caught Parker (1889, pp 83–87) records that vast numbers were taken in the Hersey branch of the Muskegon River in the early spring breeding run These fishes were slaughtered by the thousand, and no less than a half-dozen wagon-loads were hauled away Hinsdale (1932, p 15) digests information given by H B Roney[1] which testifies to the former abundance of these fishes "A party of two gentlemen and two ladies who encamped upon a stream for about a fortnight caught 3,000 greylings,

[1] *The Importance of More Effective Legislation for the Protection of Game and Fish*, Michigan Sportsmen s Association for the Protection of Fish, Game, and Birds 1879

2,000 of which were taken to Chicago, the other 1,000 not being in sufficiently good state of preservation to be transported Another party from Chicago caught, during an expedition of 4 weeks, 5,000 greylings"

At the present time graylings occur in vast numbers in Alaska Here, as formerly in Michigan, they take a fly very readily in the bright daylight In spite of the fact that they bite readily they are rather difficult to land, since their mouths are very tender They are largely insectivorous and live in rapidly moving waters The ease with which they may be caught with a fly doubtless contributed to their decrease in numbers

The former remarkable numbers of this species of fish may in part be attributed to its fecundity Jerome (1879, p 29) records that 3,555 eggs, as determined by a count were taken from a female which weighed nine ounces after their removal A large brook trout is much less prolific

In the literature there has been much discussion regarding the taste of this fish There is rather general agreement that it does not taste like either the brook or the rainbow trout According to some fishermen, it tastes like the whitefish Mr Hanselman of Ann Arbor, who has caught grayling in the Manistee River (Pl XCVIII), says that the taste and the texture of the flesh differ little from those of our native ciscoes

The causes underlying the disappearance of the grayling are unknown Several theories have been advanced Overfishing has been repeatedly mentioned as the reason for its near extinction Acid pollution from cedar logs, sawdust pollution, and log driving, have been advanced as factors in the depletion of the species Mershon (1923, pp 170 171) says, however, that after the log drives had ceased the grayling again became abundant He favors the view that the introduction of the rainbow and the brook trout were contributing factors in the disappearance of the grayling in the Au Sable and Manistee rivers The grayling have, however, persisted for some time in the Otter River in company with other trout The interrelationships of the various species may have had some bearing upon the final extinction of the grayling A theory which has not received much consideration concerns the temperature requirements of this species The clearing of the forests and the subsequent burning most certainly caused a rise in the average summer temperatures

of the streams, perhaps beyond the toleration point of these fishes, as has been indicated for the brook trout (Creaser, 1930) It should be recalled here that the grayling is a glacial relict which became established at the edge of the retreating glacier in ice-fed rivers and persisted since that time in favorable situations Mershon (1923, p 178) mentions that the temperature of the water on the Au Sable River on April 30, 1874, was 40° Fahrenheit This appears to be the only temperature record made of the water of the Au Sable during the days when it was inhabited by grayling

VIII PROBLEMS OF PROPAGATION

From the standpoint of propagation, the relative growth rates of the Montana and the Michigan grayling are extremely important There is a great possibility that the differential growth rate of grayling in the two states may be genetic rather than environmental in nature If this be true and if the grayling should prove to be desirable, the Montana grayling should be the one reared for sporing purposes The advisability of restocking our lakes and streams at this time with Montana grayling is extremely questionable The ease with which they take the fisherman's fly removes most of the element of sportsmanship in this pastime They are too easy to catch Moreover their food habits render them competitors of some of the other well-established species of trout Also attempts to plant grayling in the past have apparently met with no success at all Finally, it is strongly desirable that more information be available on its environmental requirements before plantings are attempted

For scientific purposes if for no other the Michigan grayling should be maintained and every effort should be now extended in this direction Perhaps it is even now too late

IX SUMMARY

The Michigan grayling formerly occurred widely distributed throughout the northern part of the Southern Peninsula It still persists in rapidly diminishing numbers in the Otter River in the Northern Peninsula

The Montana grayling has been planted in the Otter River, complicating studies of a systematic nature

The grayling in the Otter River grows more slowly than the corresponding species in Montana The brook trout grows somewhat

Summary of Grayling Data

Locality	Date	Age and sex	Standard length in mm	Total length in inches	Computed lengths in mm			
					I	II	III	IV
Otter River Mich	Fall, 1932	III	242	11¼	65	139	193	
	Fall, 1922	II ♂	228	10⅜	85	181		
	do	II ♂	221	10⅜	78	175		
	do	II ♂	220	10¼	72	182		
	Sept 10, 1925	I ♀	152	6⅞	88			
	do	0	90	4⅜				
	do	II ♀	238	10½	79	174		
	do	II ♀	241	11	83	193		
	do	I ♂	182	8¼	82			
	do	I ♂	173	8	87			
	do	I ♂	188	8⅝	88			
	do	I ♂	166	7¾	82			
Au Sable River, Mich	Sept 1 1900	II	258	11½	86	191		
Georgetown Lake, Mont	May 29, 1926	II ♀	250	11½	102	239		
	June 15 1933	II ♂	314	14⅝	78	233		
	do	II ♂	298	13⅞	70	223		
	do	II ♀	311	14⅝	102	251		
	do	I ♀	252	11⅞	104			
Rodgers Lake, Mont	July, 1933	IV ♂	344	15⅝	160	292	312	332
	do	IV ♂	338	15½				

more slowly than the Michigan grayling, the rainbow trout seemingly grows faster

Notes and testimony on the former abundance of the grayling are given The reasons underlying its disappearance are considered with special attention given to the neglected temperature theory

The desirability of saving the Michigan grayling from extinction is mentioned The wisdom of further attempts at planting Montana grayling at the present time is questioned

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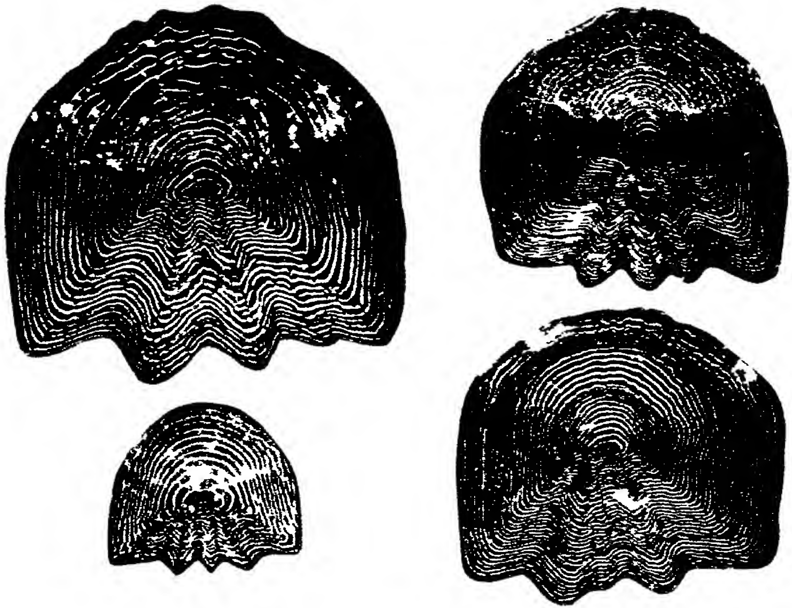
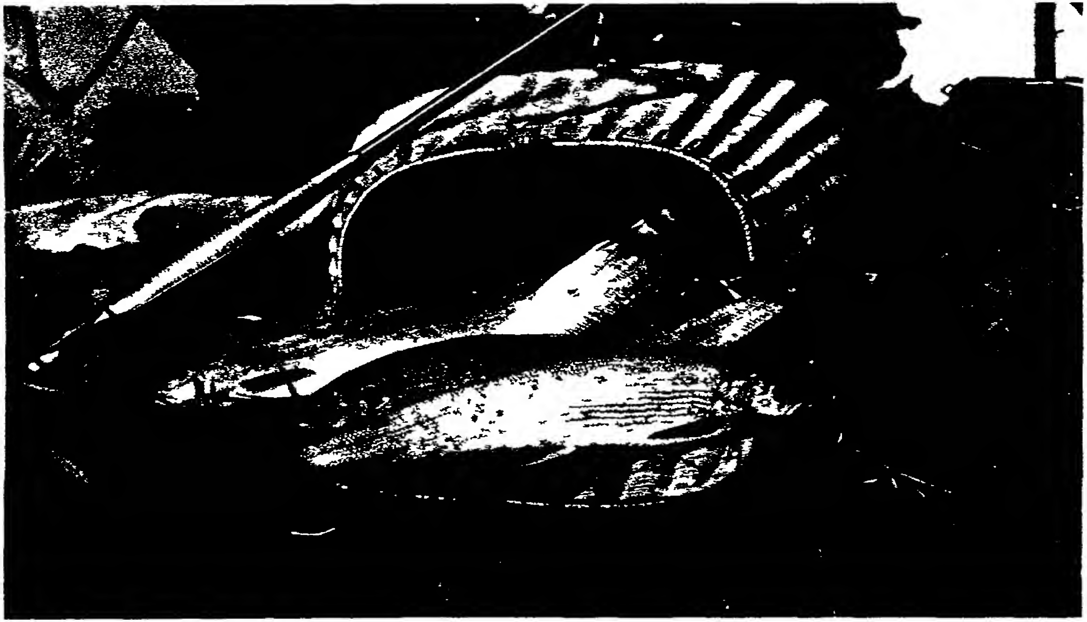
PLATE XCVII



Scales of Michigan grayling lower left at end of first growing season upper left at end of second growing season lower right at end of third growing season upper right at end of fourth growing season

PLATE X



This photograph of the Michigan grayling was made by Mr Hanselman at Ann Arbor about 1886. The specimens were taken from Bear Creek, Manistee County, Michigan, and were about fourteen inches long.

A COMPARATIVE STUDY OF THE BENTHIC FAUNA OF FOUR NORTHERN MICHIGAN LAKES *

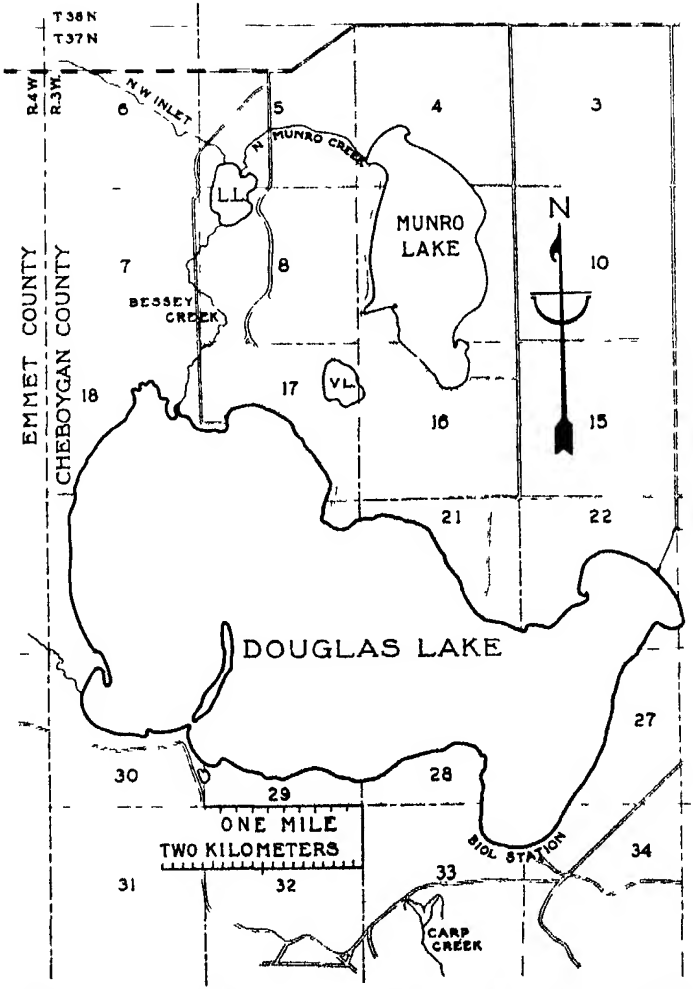
FRANK E. EGGLETON

INTRODUCTION

THE bottom fauna of a lake varies qualitatively and quantitatively not only with the seasons of the year, but also with depth, with physico-chemical conditions of the superimposed water, and with the character of the bottom deposits. These facts, now well established by such recent work as that of Miyadi in Japan, Lundbeck and Lenz in Germany, Lang in Sweden, Stanković in Yugoslavia, Decksbach in Russia, Adamstone and Rawson in Canada, and Juday, Scott, Richardson, and Eggleton in this country, were practically unknown ten years ago. Contributions to our knowledge of these phenomena have appeared frequently during the last six years. However, though these contributions have added significantly to this phase of limnology, many more such studies must be made before we shall have amassed data sufficient to justify concise statement of those basic principles which will reduce to a coherent whole what still frequently appears to be a great heterogeneity of uncorrelated facts.

The present paper offers results of a study begun in 1926 as an additional investigation while the author was primarily engaged upon another bottom-fauna problem, and aimed at a comparison of the benthic population in four lakes geographically closely situated but ecologically widely different. The investigation has been continued during the last eight years, and observations were made at irregular intervals until the summer of 1933, when the author made it his principal research project for the season. The lakes in which the study has been conducted, namely, Douglas, Lancaster, Vincent,

* Contribution from the University of Michigan Biological Station and from the Zoölogical Laboratory of the University of Michigan.



MAP 44 Douglas Lake region, showing the four lakes studied (Douglas, Lancaster, Vincent, and Munro), their connecting streams the principal roads and the township sections

and Munro, are all situated in Munro Township, Cheboygan County, Michigan, and lie within the Cheboygan River drainage basin Map 44, a sketch map prepared from an aerial photographic map made by the United States Army, shows the drainage from Munro Lake through Lancaster Lake and into Douglas Lake, which in turn empties through Maple River into Burt Lake, thence through Indian River, Mullett Lake, and the Cheboygan River into the Straits of Mackinac On Map 44 the source of Maple River is shown where it rises at the southwestern corner of Douglas Lake Vincent Lake is the only one of the four which has no surface inlet or outlet

Jewell and Brown (1929, p 449), writing about Munro Lake, state "The outlet at the north end of the lake formerly flowed into Lancaster Lake, but at the time of this study was dry most of the time Only once, during the summer of 1923, has the author observed any trace of a current in this outlet" While it is true that the volume of water entering Lancaster Lake through North Munro Creek is always small during the summer, apparently never equaling that brought in by the Northwest Inlet (Map 44), nevertheless, the present writer has never seen it dry or entirely devoid of current on any of the numerous occasions on which he has followed it throughout its length The condition described by Brown and Jewell appears, therefore, to have been abnormal Within the author's experience Bessey Creek has always maintained a continuous flow, lessened during late summer but evident even during low-water years The water level in Douglas Lake sometimes falls so low during August and September that Maple River is practically dry at its source, although farther downstream, augmented by small feeder streams, it may maintain a current

The strikingly different limnological character of the numerous lakes which lie within a radius of fifteen miles from the University of Michigan Biological Station has been known for more than a decade, and many studies dealing with various aspects of limnology have been conducted on these waters and published by Professor Paul S Welch, his students, and associates Several of these papers are concerned with one or more of the lakes studied in this investigation and some of them are of special interest in this connection Among them are the following Tucker (1913), Reighard (1915), Jewell and Brown (1924, 1926, 1929), Welch (1928), Welch and Loomis (1924), Welch and Eggleton (1932), and Eggleton (1931, 1932)

That the pronounced diversity of aquatic habitats in the vicinity of the Biological Station offered excellent opportunities for many bottom-fauna studies was evident to the author as long ago as 1923, and in 1926 Douglas, Vincent, and Munro lakes were selected for a comparative study of their benthic populations because of their marked morphometric, physico-chemical, and biological differences Lancaster Lake was actually not included in the plans of the problem until some time later, although data from certain physico-chemical determinations made during 1926 and from some bottom samples taken in the same summer are included in this paper

Professor Welch and the author have completed the field work for a joint contribution on Munro Lake, and therein will be discussed the bottom fauna of that lake in much greater detail than can be attempted here Likewise, the present writer expects to begin an intensive study of Lancaster Lake bottom fauna during the summer of 1934, and many data already at hand concerning that lake will be included in a later paper

Methods — The methods employed in this investigation have been substantially the same as those used by the author in other bottom-fauna studies, and for details the reader is referred to previous papers (Eggleton, 1931, 1932) It may here be stated, however, that bottom samples were collected with a small Ekman-Birge dredge, temperatures were taken with Negretti and Zambra thermometers, and procedures outlined in *Standard Methods of Water Analysis* were followed in chemical determinations Conductivity was determined by the use of a Digby and Biggs Dionic Water Tester (Evershed, 1911), and results are recorded in terms of reciprocal megohms

ACKNOWLEDGMENTS

The writer gratefully acknowledges the assistance of Paul S Welch, David Chandler, Donald Miller, and George W Moore in the field work of surveying Lancaster Lake Map 44 was redrawn, with modifications, from an aërial photographic map made by the Michigan Department of Conservation and the United States Army, and the author wishes to express his appreciation for the opportunity to prepare the map here published Thanks are also due to Mr Britt Riggs for permission to record certain observations on ice conditions in Douglas Lake during the spring of 1931 and to many other associates for help during the progress of the study

MORPHOMETRIC FEATURES OF THE LAKES

Douglas Lake

The morphometry of Douglas Lake has already been described by Scott (1921, pp 106–117), Welch (1928, pp 426 429), and Eggleton (1931, pp 241–243) Although clearly defined differences exist among the seven depressions of this lake, data from but two of them, South Fish-Tail and Grapevine Point depressions, have been included in the present paper South Fish-Tail depression occupies the larger part of South Fish-Tail Bay and attains a maximum depth of 24 meters It is isolated from the other depressions of the lake just below the 9-meter contour, at which level the area of this basin is 375,150 square meters Grapevine Point depression has an area of 413,940 square meters at the 9-meter isobath, and just above that depth it is isolated from all other deep-water areas of the lake

Munro Lake

Munro Lake is the second largest although the shallowest of the four lakes A detailed hydrographic map of this lake has been prepared and will appear in a subsequent paper Since the lake has a maximum length of about 1 8 kilometers, a maximum width (measured at right angles to the length) of approximately 1 2 kilometers, and a maximum depth of less than 6 meters, the slope of its floor is very gradual, in fact, the lake bed is practically level throughout most of its extent This feature is in marked contrast to the condition found in the depressions of Douglas Lake and in Lancaster Lake The data here presented for Munro Lake were gathered partly in the southern end of the lake, within Section 16 (Map 44), and partly somewhat to the north of that point, where the road forming the southeastern border of Section 4 stops at the beach

Vincent Lake

The smallest of the lakes included in this study is Vincent Jewell and Brown (1924, p 79) reported that this lake has "a maximum length of about 1600 ft and a width of about 1000 ft" Like Munro, Vincent Lake has a gently sloping floor, although, since its maximum depth approaches 7 meters and its length and width are so much less, its mean slope is somewhat greater than that of the larger lake Bottom samples have been taken throughout the whole

central basin of Vincent Lake, some of them in series extending from the deepest water up the slope to the shore line Data which from many records appear typical of the lake have been selected for inclusion in this report

Lancaster

As a basis for morphometric and biological computations a hydrographic map of Lancaster Lake was made during the summer of 1933 (Map 45) Positions of permanent monuments, over which transits were placed, are indicated by small triangles near the shore line Depths in meters of the isobaths are shown on the map As will be seen, a very considerable proportion of the lake floor lies beneath deep water Several soundings of a little more than 17 meters were made within the area included by the 17-meter contour, but are not indicated in the map

Benthic zones -- In a previous paper (Eggleton, 1931, p 245) the author defined the extent of the various benthic zones in the lakes there studied as follows " the littoral zone of the bottom is understood to mean that region lying between the shoreline and, approximately, the lakeward limit of aquatic vegetation The profundal zone extends from the greatest depths (in lakes here considered) up the slope toward shore to a point somewhat above that corresponding to the average upper limit of the hypolimnion The sublittoral lies between these two

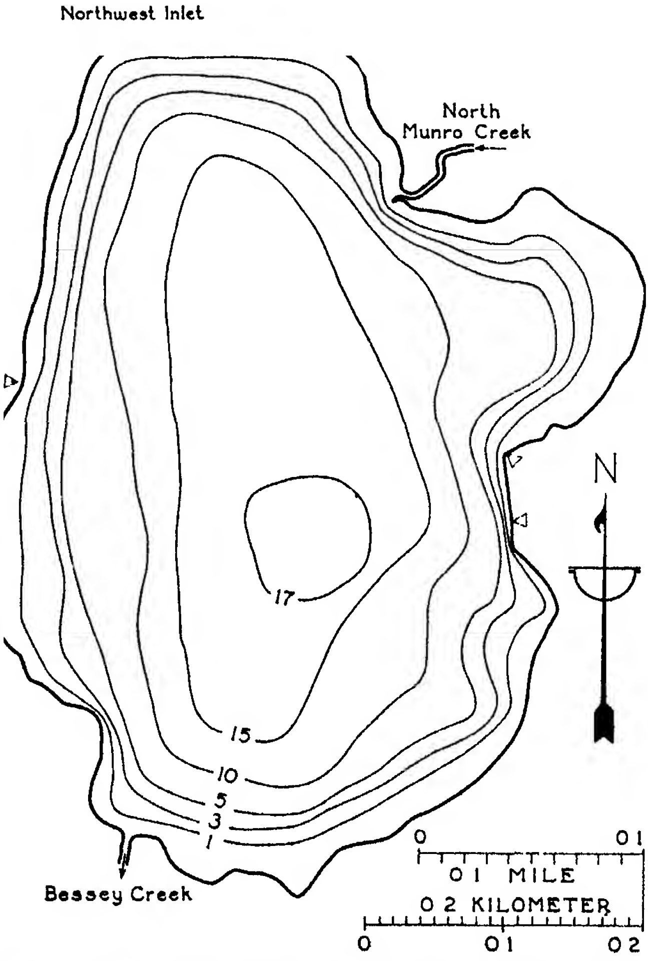
"In Douglas Lake, the littoral zone would thus extend from the shoreline to a depth of about 9 m , the sublittoral, 9–15 m , while the profundal includes all the bottom below the latter depth, 15–28 m " These definitions are here applied to Lancaster, Vincent, and Munro lakes Under their terms the benthic zones of these three lakes would have the following extent

Lancaster Lake littoral, shore line to 3-meter depth, sublittoral, 3–6 meters, profundal, 6–17 meters

Vincent Lake littoral, shore line to 1 5 meters, sublittoral, 1 5-deepest water, profundal, none

Munro Lake littoral, practically the entire lake floor, sublittoral, a relatively small area within the deepest water, profundal, none

It is thus at once apparent that these four lakes differ greatly among themselves in the character and extent of their benthic habitats



Map 45 Lancaster Lake, surveyed during the summer of 1933 The submerged contours are drawn at depths of 1, 3, 5, 10 15, and 17 meters as indicated on the map Positions of permanent monuments over which the transits were located are indicated on the shore line by small triangles in which the dot represents the exact location of the monument

Physiography and morphometry of Lancaster Lake

Maximum length	655 meters
Maximum breadth	455 meters
Mean breadth	329 meters
Maximum depth	17 5 meters
Mean depth *	8 84 meters †
Direction of main axis	north and south
Surface area	210,335 sq meters
Elevation	about 217 0 ± 1 5 meters (722 0 ± 5 0 ft)
Length of shore line	1950 meters
Shore development	1 2
Mean slope of bottom	11 5 per cent †
Volume	1,860,152 cu meters
Volume development	1 52

* Also called "reduced thickness "

† The figures were computed with formulae given by Juday (1914, p 122)

TABLE I

AREAS AND VOLUMES OF THE WATER AT VARIOUS LEVELS IN LANCASTER LAKE

Depth in meters	Areas		Stratum in meters	Volume of each stratum in cubic meters	Percentage of total volume	Underlying volume in percentage of total
	Square meters	Percentage of surface				
0	210 335	100	0–1	194 180	10 44	89 56
1	178 462	84 9	1–3	336 198	18 07	71 49
3	157 945	75 1	3–5	296 786	15 95	55 54
5	139 041	66 1	5–10	592 035	31 83	23 71
10	98 909	47 0	10–15	384 216	20 65	3 06
15	56 720	27 0	15–17	55 576	3 00	0 06
17	6 884	3 3	17–17 5	1 161	0 06	0 00
17 5	0 3		Total	1 860 152	100 00	0 00

TABLE II

LENGTH OF CONTOURS AND AREAS BETWEEN CONTOURS IN LANCASTER LAKE

Depth in meters	Length of contour in meters	Stratum in meters	Area between contours in square meters	Percentage of total area between contours
0	1950	0–1	31 873	15 2
1	1725	1–3	20 518	9 7
3	1590	3 5	18 904	9 0
5	1500	5–10	40 131	19 1
10	1260	10–15	42 190	20 0
15	1025	15–17	49 835	23 7
17	2900	17–17 5	6,884	3 3
17 5	1	Total	210 335	100 0

Comparison of the morphometry and physiography of the lakes

These four lakes vary greatly from one another in many respects. On the basis of certain morphometric measurements they can be placed in two classes, and on the bases of the physical and chemical nature of their waters and of several biological criteria they can likewise be classified into different groups. It is a noticeable fact, however, that whenever the new criteria of classification are adopted the grouping of the lakes is apt to be different. Thus, if these four alone are considered, Douglas and Munro are large lakes, Vincent and Lancaster are small ones. If, now, they be separated on a basis of depth, Douglas and Lancaster belong in the same category and Munro and Vincent in another. If the lakes are grouped according to inflowing and outflowing streams, Douglas and Lancaster are alike in that they both have inlets and an outlet, while Munro is different from either of them in having an outlet but no true flowing inlet, and Vincent, with neither visible inlet nor outlet, is alone in a third class. Though exact figures for Vincent and Munro remain to be computed, yet when they are compared with the known facts concerning mean slope of the bottom in Douglas and Lancaster, it seems certain that the four lakes could be arranged in a series showing rather constantly decreasing abruptness of slope from Lancaster through Douglas and Vincent to Munro. Many more such classifications of these lakes could be made on the basis of the different morphometrical, physical, chemical, and biological features which they exhibit. Such extensions would, however, serve only to illustrate further a fact already well established. No one of the lakes is like any of the others in all of its characteristics.

PHYSICO-CHEMICAL FEATURES OF THE LAKES

The four lakes are quite as distinct from one another in their physical and chemical constitutions as they are in their morphometrical features. Tables III–V present physico-chemical data showing in a comparative manner vertical variation of these factors in each of the lakes at three different seasons of the year, early spring, midsummer, and late autumn. Table VI contains a summary of certain thermal and chemical data obtained in the four lakes during the years 1926–33. In all these tables the data included have been selected for a few dates from among many complete series in order

to illustrate the physico-chemical conditions typically present in these lakes

Douglas Lake

In Douglas Lake physico-chemical conditions are greatly different in each of the seven major depressions However, since but two of these regions of deep water are considered in this paper, they alone will be discussed in this connection South Fish-Tail depression is typically stratified thermally in summer and likewise shows well-developed chemical stagnation within the hypolimnion during the latter part of the summer season Surface temperatures are seldom as high as those encountered in the smaller lakes, and the fall in temperature within the ordinarily rather extensive epilimnion is frequently slight Secondary thermoclines occasionally are present

Table III contains data secured by the author in the spring of 1931 (April 14–17) At that time the vernal overturn was in progress, and Douglas Lake was homothermous from top to bottom, with the temperature at 3 6 in South Fish-Tail depression and somewhat higher, 3 8, in Grapevine Point depression In respect to pH of the water, amount of dissolved oxygen, and free carbon dioxide, the two depressions were practically identical

So far as the writer is aware, no record has ever been published concerning disappearance of the ice from this lake in spring It therefore becomes of interest to record the following facts in connection with the physico-chemical data in Table III Mr Britt Riggs, caretaker of the Biological Station, reports that on April 4, 1931, there was solid ice 18–24 inches thick on the lake and cars were being driven over it On April 8 the ice was still solid, and in but one small place was there any evidence of its beginning to break away from shore On April 11, however, the ice began to break up rapidly and on April 12, under the combined influence of warmer weather and a high wind, most of the ice went out of the lake The wind, although somewhat abated, continued fresh on April 13 and shifted into the northwest, with the result that all the remaining ice was pushed into South Fish-Tail Bay When the writer arrived at the Biological Station at 6 00 P M , April 14, the ice extended from in front of the center of the Station grounds lakeward to a point somewhat east of the center of the bay and then tapered off in a northwesterly direction to near the tip of Grapevine Point (Section 28, Map 44) There was

thus an ice field, composed entirely of small cakes 2–3 meters in diameter or smaller, occupying the whole southwestern portion of South Fish-Tail Bay. The following morning this ice was frozen firmly together, but during the day it broke up again, melted considerably, and by night had shrunk to an area hardly more than a hectare (2.47 acres) in extent and was entirely composed of long, cylindrical "crystals," about 2 centimeters in diameter and 20–25 centimeters in length, which floated upright in the water and arranged themselves in a honeycomb formation. The following day, April 16, this field of "crystals" shifted to a position directly in front of the Station and by that night had shrunk to less than half the area it had occupied on the previous day. About 7:00 A.M., April 17, when the writer left the Station, a fresh wind from the southwest was fast carrying this ice out into the lake and scattering it widely. During these three days, April 15–17, there had been no perceptible change in the early-morning surface temperature of the water in South Fish-Tail Bay.

Munro Lake

The slight depth of this body of water is reflected in the rapidity of its temperature changes. During the hot weather of summer little difference exists between surface and bottom temperatures and they are uniformly high (Table IV). In spring the lake warms up quickly (Table III), and in autumn it cools off more quickly than any of the others (Table V). It almost never stratifies thermally. The only thermocline found there by the author was on July 20, 1932 (Table VI), and even then it was just beneath the surface and was plainly ephemeral. The pH of this lake is always on the alkaline side of the scale, and there is never more than a slight vertical variation. In fact, the most noticeable physico-chemical feature of the lake is its practical uniformity from top to bottom at all seasons of the year (Tables III–VI).

Vincent Lake

The one thing which, from a physico-chemical standpoint, most clearly characterizes Vincent Lake is the acid reaction of its water. Jewell and Brown (1924) found the pH to be as low as 4.4 and reported in a later paper (Brown and Jewell, 1926, p. 23) that in 1925 "samples from this lake were consistently 4.4 between July 1 and

July 29," but that, "When the water was tested, August 11 and 12, it was found to have a pH of 6 4 " In a third paper (Jewell and Brown, 1929, p 455) these authors report an extreme variation in Vincent Lake from pH 4 4 to 7 2 for the years 1923 26 During the course of the present investigation the pH was found to vary from 5 7 to 7 0 at the surface and between 5 4 and 7 0 at the bottom (Table VI) for the years 1926-33

Lake Munro, this lake very seldom shows thermal stratification and typically has an abundance of dissolved oxygen from surface to bottom The water is very soft The amount of carbonates present is but a small fraction of that found in the water of Douglas, Lancaster, and Munro lakes (Table VI) Being shallow, the water warms up quickly in the spring (Table III), becomes warm throughout in summer (Tables IV and VI), and cools off early in the autumn (Tables V VI) One of the more recently added routine analyses used by the writer in the study of these lakes has been that of conductivity or specific conductance Tables IV and V show that, of the four lakes studied, the waters of Vincent Lake were by far the lowest in electrolyte content, having less than one tenth of the amount present in Douglas Lake However, Vincent Lake has a noticeably higher specific conductance than that of the majority of seepage lakes studied by Juday and Birge (1933) in northeastern Wisconsin They reported (p 237, Table IX) that of 238 seepage lakes investigated slightly more than 86 per cent gave conductivity readings of less than 20, the value shown for Vincent Lake in Table IV of this paper

Lancaster Lake

Although a relatively small lake, Lancaster has a considerable depth for a body of water of its size This feature, together with the steep slope of its floor and the protection afforded it from the prevailing winds of the region by surrounding hills and forests, results in a very abrupt thermocline, ordinarily located near the surface Summer surface temperatures run rather high and bottom temperatures decidedly low for a small lake in that latitude and with a maximum depth of only 17 meters Table V shows that the lake cools off slowly in autumn, and in this respect it stands sharply in contrast to the shallow Munro Lake

And again in contrast to the other three lakes, the water of

Lancaster Lake is rather highly colored. Measured with the standard comparator of the United States Geological Survey the brown color of this water showed a value of 59 on the platinum-cobalt standard scale. Associated with the abruptness of thermal stratification there is ordinarily present a well-developed chemical stagnation within the hypolimnion. Oxygen disappears from the lower water quite early in the summer and by late July is often wholly absent below depths of 10 or 12 meters (Tables IV and VI). The water is typically alkaline in its reaction, only rarely falling below 7.0 on the pH scale, and carries considerable amounts of dissolved substances as indicated in Tables IV–VI.

THE BENTHIC FAUNA OF THE LAKES

In Vincent and Munro lakes the bottom-fauna sampling series have extended from the deepest water up to depths of one meter. In Lancaster Lake the series have extended from the 17-meter depth up the slopes to the 2-meter contour, while in Douglas Lake they have not extended above the 8-meter isobath. Representative series from each of the lakes have been selected and the data are presented in Tables VII–X. These tables show both qualitative and quantitative variations of bottom fauna in each lake at different depths and at different seasons of the year.

Seasonal Variations

Qualitative. — The benthic population on any region of a lake floor was found not to be qualitatively the same at all seasons of the year. This fact was particularly evident in the littoral and sublittoral zones, but even within the profundal zone in Douglas and Lancaster lakes certain forms which were present at one season of the year were not always there at other times. As was demonstrated by the author's earlier work on the profundal benthic fauna, the animals typically present within that zone on the floor of Douglas Lake included representatives of the genera Corethra, Chironomus, and Protenthes, and of the families Tubificidae and Sphaeriidae. Tables VII, VIII, and X show clearly that the same taxonomic groups are represented in the profundal benthic fauna of Lancaster Lake, but that not every one of these groups is represented in the profundal benthic fauna at all seasons of the year in either Douglas or Lancaster. Thus, on August 10, 1933, neither Chironomus nor Protenthes larvae

were taken below 6 meters in Lancaster Lake, although Corethra larvae, Tubificidae, and Sphaeriidae were present even at 16 meters, whereas a little more than a month previously specimens of each of these five groups were found at the 15-meter depth

The clearest evidence of the qualitative seasonal variations within the benthic fauna is to be found, however, in the column headed "All others" in the tables Within the profundal zone of Douglas Lake depressions and within the same zone in Lancaster Lake this group disappears during the summer stagnation periods, but appears again during the autumnal overturns Only a few autumnal records are available for these lakes, hence it is not known how far into their profundal regions the members of this heterogeneous group of benthic animals may penetrate, although the more nearly complete records in Third Sister Lake (Eggleton, 1931) indicate that they probably spread out over the whole profundal zone during the period of the overturn

Quantitative — The total quantity of the benthic population, whether considered at any particular depth within any one of the three zones, or over the lake floor as a whole, was found to vary greatly from one season of the year to another In the tables the last column, which gives the "Total," reflects this great seasonal variation in the density of the benthic fauna

No spring records for any of these lakes have ever been published before, and the only records known to the author are those presented in Table IX These data were secured on April 15 and 16, 1931, immediately after the ice broke up and just at the inception of the vernal overturn The benthic population within the sublittoral and profundal zones was much greater at that time than it was during the following July, and was also greater than during August, 1933 (Table VII) However, the benthic population found within the same zones of the same depression on November 5, 1933, was much more dense than it was even in the spring of 1931 Whether this is due to a difference between the productivity of the lake floor during 1931 and that during 1933 or to losses suffered by the benthic fauna during the winter, is, of course, debatable The writer is of the opinion, however, that either cause might account for the difference, but that probably both of them were concerned

That the productivity of the benthic zones varies from year to year is evident from a comparison of the data presented concerning

this depression for July 9, 1931, and for August 14, 1933 (Tables VII and IX) The 1933 data show that the bottom fauna was considerably more abundant in that year than in 1931 However, the records for the former year were taken more than a month later in the season than were those of the latter It must be admitted that the emergent forms began to appear as adults earlier in 1931 than they did in 1933, but even among the nonemergent types the total bottom population appears to have been heavier in 1933 than it was two years earlier

Quantitative seasonal variation of the bottom fauna in Lancaster Lake is as evident as it is for Douglas Lake On November 4, 1933 (Table VIII), the total number of organisms per square meter of lake bottom in Lancaster Lake was much greater throughout the sublittoral and profundal than it had been at the same depths on the preceding August 10 (Table VII) The number of Corethra larvae in particular had increased greatly by November, and likewise the Chironomus larvae were more numerous in the autumn than in the summer, while certain other forms were less abundant at the levels sampled However, it is the "Total" column which again demonstrates most clearly this seasonal variation in the benthic fauna When this last column is compared in Tables VII, VIII, and IX, it will be seen that in each of the two lakes there is a pronounced rise and fall in the total bottom population as the *four limnological seasons of the year* — vernal overturn, summer stagnation, autumnal overturn, and winter stagnation — follow each other in the manner typical of temperate-zone lakes of the second order

Despite the fact that Vincent and Munro lakes are greatly different from Douglas and Lancaster in so many ways, they nevertheless manifest many points of similarity in the nature and behavior of their benthic faunas This fact is strikingly true in respect to quantitative variations of the bottom populations during the different seasons of the year (Tables VII, VIII, and X)

Depth distribution

When the writer began an investigation of profundal bottom fauna in Douglas Lake, early in the summer of 1923, one of the first aims of that study was to determine whether or not the bottom population was either qualitatively or quantitatively uniform over the whole lake floor beneath the deeper water In order to ascertain the distribution of the benthic population samples were taken in

series, usually beginning with a set where the water was deepest, followed by a second set somewhere up the slope where the water was one or two meters shallower, a third set still farther up the slope where the water was still shallower, and so on up the sloping sides of the lake basin until the littoral or sublittoral zone was reached, where the series were usually discontinued It was evident, after only a few such series had been taken, that at least in that lake the bottom fauna was neither qualitatively nor quantitatively evenly distributed over the bottom

When, in June, 1926, the present study was begun, three years of experience had demonstrated to the author that typically the benthic fauna was not evenly distributed in any lake yet studied By that time the early quantitative investigations on bottom fauna had appeared, and other workers were also finding and beginning to report a lack of uniformity in depth distribution of benthic populations in some of the European and North American lakes It was Ekman who really led the way into quantitative bottom-fauna research by his paper which he published in 1915 under the title, "Die Bodenfauna des Vättern, qualitativ und quantitativ untersucht" Muttkowski (1918) had reported on his studies of bottom fauna in the shallower waters of Lake Mendota, and Juday (1922) carried on the work in that lake by investigating, quantitatively, the bottom fauna in its deeper waters Previously Baker (1916, 1918) had presented results of his studies on the mollusks and invertebrate fish food from the bottom of Oneida Lake, and in 1921 Richardson published the first of a series of investigations dealing with small shore and bottom animals of the Illinois River and its connecting lakes And there were others, both in America and in Europe Adamstone and Harkness (1923) and Adamstone (1924) wrote concerning bottom fauna in Lake Nipigon With their work and with that of Schmassmann (1924) and Lundbeck (1926) depth distribution began to be considered an important part of bottom-fauna studies, and data concerning this phase of benthic ecology came gradually to be presented and discussed as they are today

The representative records presented in Tables VII–X indicate clearly certain facts concerning depth distribution of bottom fauna in these four lakes It is evident, for instance, that the benthic fauna is not uniformly distributed over the bottom from shore to the deepest water This has been found to be universally true for all

lakes studied, in all parts of the world, so far as the author is aware Tables VII IX also show that each different kind of bottom animal has a depth distribution which frequently is unlike that of any other member of the association Different species within the same genus are often distributed differently with depth Furthermore, the same species is often distributed differently in different lakes An example of this phenomenon is to be found in the distribution of Chironomus larvae in South Fish-Tail depression, Douglas Lake, on August 14, 1933, and in Lancaster Lake on August 10 of the same year In the samples from both lakes the chironomid fauna on that date was largely composed of *Chironomus plumosus* L In Lancaster Lake these larvae exhibited an unusually uniform distribution down to 6 meters, but at that depth ceased suddenly and none were taken in deeper samples In contrast, larvae were found in South Fish-Tail depression of Douglas Lake at all depths from 9 to 22 meters, and instead of showing a uniform distribution they increased in abundance with increase of depth down to 13 meters, but below that decreased steadily and rapidly with increasing depth, until at 22 meters the density of population was the same as at 9 meters (Table VII) Other examples of the same kind of variation in depth distribution can be found in these tables

One feature concerning bottom-fauna depth distribution in the lakes which is irrefutably demonstrated by these data, but which is either ignored or doubted by some workers, is that the depth distribution found at one time of the year cannot be assumed to be the distribution typical of that type of lake or even of that individual lake at all other times of the year This fact could be demonstrated for each group making up the benthic fauna, but it is especially clear when the total bottom population is considered Comparison of data contained in the last, i e "Total," column of Tables VII and VIII for each of the four lakes and of data in the same column of Table IX for South Fish-Tail depression, Douglas Lake, will show this fact clearly Figures 50 and 51 are graphs depicting depth distribution of the total bottom population in these four lakes in summer (Fig 50) and in Douglas and Lancaster lakes during the autumnal overturn (Fig 51) If the curves for these lakes in Figure 50 are compared with those for the same two lakes in Figure 51, it will be seen that distribution of the bottom animals had changed in several respects The number of animals per square meter of lake floor be-

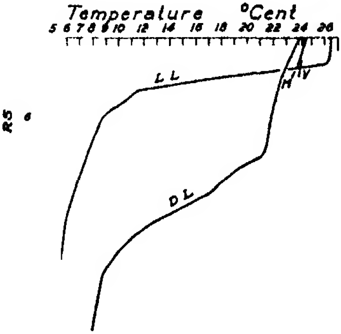


Fig 47

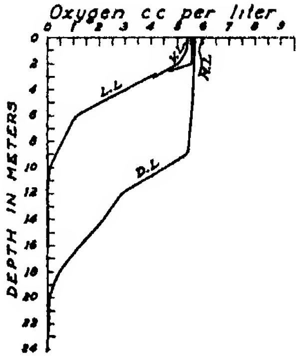


Fig 48

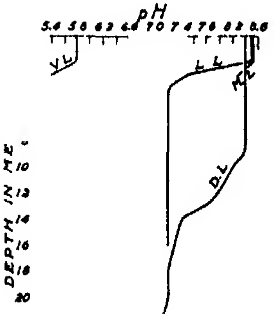


Fig 49

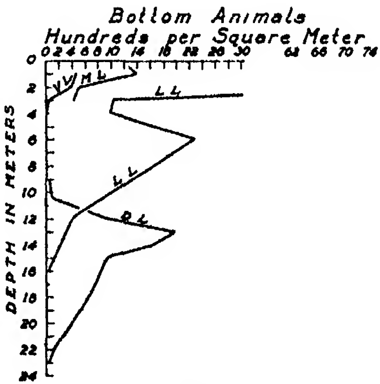


Fig 50

Figs 47–50 In numerical sequence these figures indicate vertical variation of temperature in degrees Centigrade, of dissolved oxygen in cubic centimeters per liter, and of hydrogen ion concentration, and vertical distribution of bottom animals in hundreds per square meter in Douglas Lake (D L), Lancaster Lake (L L), Vincent Lake (V L), and Munro Lake (M L), in the summer of 1933

neath the deeper water was greater in the autumn than during the summer, but in shallow water the reverse was true, and autumnal populations were less dense than were those of summer Furthermore, the region of maximum abundance occurred at a deeper level in November in both lakes than it did during the preceding summer

Concentration zone — In 1931 the writer pointed out the existence of a zone within which the benthic fauna was very much more abun-

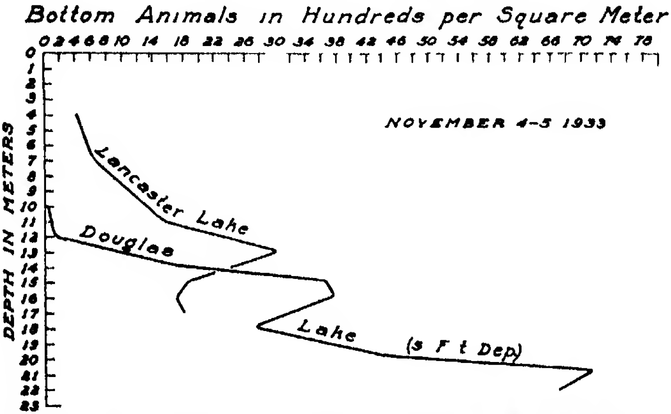


FIG 51 Vertical distribution of bottom animals in hundreds per square meter, on November 4-5 1933, in Douglas Lake South Fish Tail depression, and in Lancaster Lake

dant than it was either above or below that region of the lake floor, called this part of the benthic habitat the "*concentration zone*", and demonstrated that it shifts up and down the slope of the lake floor with the change of the seasons Miyadi (1931, 1932, 1933) has found the same phenomena occurring in Japanese lakes Figure 51 shows the existence of such a concentration zone in Lancaster Lake and likewise redemonstrates its existence in Douglas Lake at the same time It is very interesting to note the similarity between the Douglas Lake curve in this figure and the curve for depth distribution of bottom fauna in the same region of that lake on October 20, 1928 (Eggleton, 1931, Fig 55, p 275) Although the maximum number of organisms present is different and although the 1933 curve shows a deeper distribution of the fauna on that date than on

October 20, 1928, the two curves are essentially alike in their important features Even more pronounced is the similarity between the curve of November 4 5, 1933, for Lancaster Lake and that for Third Sister Lake on November 8, 1927 (Eggleton, 1931, Fig 37, p 270) Evidently that sort of distribution is typical during that *limnological season of the year* in certain kinds of lakes

No record of midwinter bottom-fauna depth distribution has ever been taken in any of these lakes But early in the spring of 1931 sampling series were taken by the author to determine the distribution at that time in South Fish-Tail and Grapevine Point depressions of Douglas Lake The records for South Fish-Tail depression in Tables IX, VII, and VIII, when studied in that order, indicate that in Douglas Lake the concentration zone occurs in the lower profundal during late winter and early spring, occupies the upper profundal and lower sublittoral during that part of the summer when stagnation of the hypolimnion is most severe, and again shifts down into the profundal with the coming of the autumnal overturn The curves indicating depth distribution of total bottom population in Douglas and Lancaster lakes during the summer of 1933 (Fig 50) and on November 4-5, 1933 (Fig 51), also show the position of the concentration zone in summer and the fact that it shifts down the slope with the onset of the autumnal overturn These curves likewise indicate the very considerable increase in the total number of benthic organisms on the lake floor as a whole

Effect of physico-chemical factors

One of the most powerful sets of factors found to be influencing the qualitative nature, the abundance, and the depth distribution of the benthic fauna in these lakes was that imposed by the physicochemical nature of the water in the limnetic zone of the lake Figures 47-50, indicate, in numerical order, the vertical variation of temperature in degrees Centigrade, of dissolved oxygen in cubic centimeters per liter, and of hydrogen ion concentration, and the vertical distribution of bottom animals in hundreds per square meter in Douglas Lake (D L), Lancaster Lake (L L), Vincent Lake (V L), and Munro Lake (M L), in the summer of 1933 These figures show that thermal stratification and chemical stagnation constitute a powerful set of factors

Lundbeck (1926) appears to favor the hypothesis that tem-

perature is the controlling factor in distribution of the chironomid fauna Miyadi (1931*a*, pp 223–224) upholds the thesis that dissolved oxygen is the determining factor and states "In general, chironomid and *Corethra* larvae are most numerous and most widely distributed after spawning and their active migration results in a typical distribution for each lake, probably determined for each species by the amount of dissolved oxygen Most of the bottom inhabitants seem to be indifferent to the temperature of the water, e g the larvae of *Endochironomus* and *Corethra* are found in both alpine and baltic lakes The[1] depth at which they live is determined by the oxygen content, and their migration is a response to the change of oxygen content of the water"

The present writer is of the opinion that neither of these positions can be successfully defended against all available evidence from field and laboratory studies It has been demonstrated (Eggleton, 1931) that any one of several environmental factors can be varied so far from the optimum for these benthic animals as to be lethal and that certain members of this benthic fauna can be killed by prolonged exposure to the most severe stagnation conditions within the lower profundal of the lakes themselves It appears doubtful, however, whether within the range of variation normally to be expected in the natural habitats of these animals, any *one* factor could vary so far as to become lethal or even so seriously unfavorable as to cause wholesale migration Rather, it seems that the more probable explanation of the observed facts is to be found in the combined effect of all factors operative in the environment Small changes in a certain factor are often more effective when accompanied by changes in other factors than are relatively large changes in one factor alone Also, some of these physico-chemical variations may in certain instances be most effective in producing migrations of an organism through their effect upon the food supply of that organism The environment, even when so stable as that in the profundal benthic zone, is always complex And actually in nature each of these physico-chemical variations always takes place in the presence of all the other factors of the environment

It seems certain, moreover, that the combined effect of these physico-chemical factors, when they vary to any considerable degree, is a powerful one in the ecology of the benthic fauna In Lancaster

[1] This word occurs in the original as "They"

Lake, for instance, the character of the bottom does not change greatly between 2 and 4 meters, but the physico-chemical factors often do, as Figures 47–49 show The effect of these changes upon the quantitative distribution of bottom fauna is at once apparent from a study of Figure 50, which shows this fauna dropping from 7,300 individuals per square meter at a depth of 2 meters to but a little over 1,000 per square meter at the 4-meter depth Table VII indicates in the last two columns, "All others" and "Total," the correspondingly great qualitative change within the same short depth range Thus in Lancaster Lake on August 10, 1933, there were 6,585 animals per square meter of bottom at the 2-meter depth, which were recorded in the column for "All others" This category contained all animals present except Corethra, Chironomus, Protenthes, Tubificidae, and Sphaeriidae It was a heterogeneous group and contained representatives from several phyla and from many orders of invertebrates At 3 meters this group had decreased to a total of 308 individuals per square meter, and these were restricted to a very few orders, whereas at the 4-meter depth none of them were present, and the entire benthic fauna had changed to the typical profundal benthic types

SUMMARY

1 Representative data selected from a much larger number are presented concerning four northern Michigan lakes, Douglas, Lancaster, Vincent, and Munro, all of which are in Cheboygan County The data deal with physiography and morphometry of the lakes, physico-chemical features of their waters, qualitative and quantitative seasonal variations, depth distribution, the concentration zone, and relations to environmental factors of the benthic fauna An original hydrographic map of Lancaster Lake and a sketch map redrawn from an aerial photographic map of the Douglas Lake region are included The period covered by the study was from June, 1926, to November, 1933

2 Data from two Douglas Lake depressions are included in this paper, the majority being from South Fish-Tail depression This lake is the largest of the four studied, shows typical thermal stratification and chemical stagnation during the summer, and has a profundal benthic fauna composed of representatives of the genera Corethra, Chironomus, and Protenthes, and of the families Tubificidae and Sphaeriidae Spring, summer, and autumn records are included

3 Munro is the second largest lake of the four, but is shallow, shows no thermal or chemical stratification, is intermediate in abundance of its bottom fauna, and, like Douglas Lake, is slightly alkaline

4 Vincent, a small acid lake, is quite shallow, seldom shows any thermal stratification, has soft water which is low in dissolved substances, and supports a bottom fauna in some respects different from those of the others, but in many ways surprisingly like those of the other three lakes

5 Lancaster ranks second in depth and third in size It is the only one whose waters are noticeably colored, and it is remarkable for the abruptness of its thermal and chemical stratification and for the proximity of the thermocline to the surface In many respects its bottom population is like that of Douglas Lake, especially in the profundal zone, where the same typical benthic fauna is found

6 The bottom population varied qualitatively and quantitatively in each lake with the seasons of the year It also varied quantitatively within the same lake from year to year

7 Despite the great differences in size, shape, and nature of the basin and in the character of the water and of the bottom deposits, one of the most evident features of the bottom faunas of these lakes was their marked similarity, particularly in the deeper water Data to appear in later papers will show greater differences between their littoral faunas

8 The bottom fauna was not evenly distributed over the floor in any of these lakes, but varied with depth, somewhat differently in each of the lakes, and very differently in the *four limnological seasons of the year*

9 Some species of animals are distributed differently in the several lakes, one example of which is seen in the distribution of *Chironomus plumosus* L in Douglas and Lancaster lakes

10 Data presented irrefutably demonstrate that the depth distribution found in any particular lake at one time cannot always be assumed to be typical of that type of lake or even of that individual lake at all other times of the year

11 It was redemonstrated (*a*) that a "*concentration zone*" occurs in Douglas Lake, and it was shown (*b*) that this feature of depth distribution is also present in Lancaster Lake, and (*c*) that in both lakes it shifts up and down the slope of the lake floor with the change

of seasons It was found to be present in the lower profundal during early spring, in the upper profundal and lower sublittoral in summer, and in the lower profundal again during the autumnal overturn

12 It is maintained by the author that the explanation of the observed facts of distribution is probably to be found not in the effect of any one environmental factor, but rather in the combined effect of all the factors operating together

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EXPLANATION OF TABLES III–X

In the tables which show variation of physico-chemical factors temperatures are expressed in degrees Centigrade, depths in meters, dissolved oxygen in cubic centimeters per liter, free carbon dioxide in parts per million, methyl orange alkalinity in parts per million of calcium carbonate, and conductivity in reciprocal megohms

Abbreviations used in the tables are *alk*, alkalinity, *B*, bottom, *c c per l*, cubic centimeters per liter, *Cent*, Centigrade, *Cond*, specific conductance or conductivity, *Gr P dep*, Grapevine Point depression, *M O*, methyl orange, *Mus*, Musculium, *n s*, not stratified, *pH*, hydrogen ion concentration, *Pis*, Pisidium, *p p m*, parts per million, *S*, surface, *S F-T dep*, South Fish-Tail depression, *Sph*, Sphaerium, *Temp*, temperature, *U L H*, upper limit of the hypolimnion Other abbreviations used are too well known to need explanation

TABLE III

COMPARISON OF PHYSICO-CHEMICAL FACTORS IN DOUGLAS, VINCENT AND MUNRO LAKES

Douglas Lake, S F-T dep April 15 1931					Douglas Lake Gv P dep April 15 1931					Vincent Lake north end April 16 1931					Munro Lake Station 42 April 16 1931				
Temp Cent.	pH	O_2 c c per L	Free CO_2 p p m	M O alk p p m	Temp Cent	pH	O_2 c c per l	Free CO_2 p p m	M O alk p p m	Temp Cent	pH	O_2 c c per l	Free CO_2 p p m	M O alk p p m	Temp Cent	pH	O_2 c c per l	Free CO_2 p p m.	M O alk p p m.
3 8	7 4	6 0	3 0	126	3 8	7 4	6 0	3 0		9 0	6 0	6 0	3 0	6 0	7 8	8 0	6 1	0 0	110
3 6					3 8					9 0	6 0	6 1	3 0	6 0	7 5	8 0	6 0	0 0	110
3 6	7 4	6 0	3 0		3 8														
3 6	7 4	6 0	3 0		3 8														
3 6		6 0		127	3 8	7 4	6 0	3 0											
3 6	7 4	6 0	3 0		3 8														
3 6	7 4		3 0																
3 6	7 4	6 1	3 0	128	3 8	7 4	5 9	3 0											
3 6	7 4		3 0																
3 6	7 4		3 0																
3 6	7 4	6.0	3 0	128	3 8	7 4	6 1	3 0											
3 6	7 4		3 0																
3 6																			
3 6	7 4		3 0		3 8	7 4		3 0											
2.6																			
3.6	7 4	5 9	3 0	128	3.8	7 4	5 6	3 0											
3.6	7 3	5 9	3.0	130	3.8	7 4	5 5	3 5											
3.6																			

TABLE IV

COMPARISON OF VERTICAL VARIATION OF PHYSICO-CHEMICAL FACTORS IN DOUGLAS LANCASTER, VINCENT AND MUNRO LAKES

Depth in meters	Douglas Lake S. F-T dep. July 21 1933						Lancaster Lake, center July 31 1933						Vincent Lake north end July 28, 1933						Munro Lake, Station 50 August 3 1933					
	Temp Cent	pH	O_2 c.c. per l	Free CO_2 p.p.m.	M O alk. p.p m	Cond	Temp Cent	pH	O_2 c.c per l	Free CO_2 p p m.	M O alk. p p.m	Cond	Temp Cent	pH	O_2 c c per l	Free CO_2 p p m	M O alk. p p m	Cond	Temp Cent	pH	O_2 c c. per l	Free CO_2 p.p m.	M O alk p p m	Cond
0	24.0	8.4	5.7	0.0	129	225	28.4	8.5	5.6	0.0	148	240	24.3	5.8	5.4	2.0	11	20	24.5	8.5	6.0	0.0	118	185
1	23.6						28.4	8.5		0.0			24.3	5.8	5.4	2.0	11	20	24.3	8.5	5.8	0.0	117	185
2	23.0						26.2	8.5	5.6	0.0	148	240	24.15	5.8	5.1	2.0	11	25	24.0	8.5	5.9	0.0	118	187
3	22.6	8.4		0.0			18.2	7.5	4.0	5.0	142	225	23.9	5.4	4.1	5.0	12	22.5	23.4	8.3	5.8	0.0	116	190
4	22.3						11.4	7.2	3.0	8.0	140	225												
5	22.1	8.4	5.6	0.0	130	225	10.3	7.2		8.0														
6	21.9						8.8	7.2	1.1	8.0	150	250												
7	21.7						8.3																	
8	21.6						8.0	7.2																
9	21.3	8.4	5.4	0.0	130	225	7.6																	
10	19.4	8.2		0.0			7.1	7.2	0.14	9.0	176	310												
11	18.1						6.8	7.2	0.0															
12	17.2	8.0	2.9	0.0	130	225	6.5	7.2																
13	15.2	7.8		1.0			6.3																	
14	13.0	7.4	2.2	5.0	130	225	5.9	7.2	0.0	10.0	207	350												
15	11.5						5.8																	
16	10.4	7.3	1.35	6.0	131	225	5.7	7.3	0.0	12.0	209	350												
17	9.6						5.6																	
18	8.8	7.2	0.42	7.0	131	225																		
19	8.6																							
20	8.4	7.3	0.14	7.0																				
21	8.2																							
22	8.1	7.1	0.0	8.0	132	230																		
22.5	8.0																							

TABLE V

Comparison of Vertical Variation of Physico-chemical Factors in Douglas, Lancaster, Vincent and Munro Lakes

Depth in meters	Douglas Lake, S. F–T dep. November 5, 1933						Lancaster Lake, center November 4 1933						Vincent Lake center November 4 1933						Munro Lake, Station 42 November 4 1933					
	Temp Cent.	pH	O_2 c.c. per l	Free CO_2 p.p.m.	M O alk p.p.m.	Cond	Temp Cent	pH	O_2 c.c. per l.	Free CO_2 p.p.m.	M O alk. p.p.m.	Cond	Temp Cent	pH	O_2 c.c. per l	Free CO_2 p.p.m.	M O alk. p.p.m.	Cond	Temp Cent	pH	O_2 c.c. per l	Free CO_2 p.p.m.	M O alk. p.p.m.	Cond
0	5.8	8.1	8.2	0.0	136	220	6.6	7.6	5.9	5.0	166	300	5.4	6.2	8.1	2.0	8.0	28	3.6	7.8	8.5	2.0	104	180
1							6.6						5.4	6.2		2.0	8.0	28	3.6	7.8	8.5	2.0	104	180
2	5.8						6.6						5.7	6.2	8.0	2.0	8.0	28	3.6	7.8	8.3	2.0	104	180
3							6.6						6.0	6.2	7.8	2.0	8.0	30						
4							6.55						7.2	6.2										
5	5.8	8.1	8.2	0.0	136	220	6.5	7.6	5.9	5.0	167	300	10.6*											
6							6.5																	
7							6.4																	
8	5.8						6.4																	
9							6.4																	
10	5.8	8.1	8.2	0.0	136	220	6.4	7.5	5.8	5.0	170	300												
11							6.4																	
12	5.8						6.35																	
13							6.35	7.5	5.3	5.0	172	300												
14							6.3																	
15	5.8	8.1	8.2	0.0	136	220	6.3																	
16							6.3	7.5	4.9	5.0	175	[illegible]												
17							6.2†																	
18	5.8																							
19																								
20	5.8	8.1	8.2	0.0	136	220																		
21																								
22	5.8	8.1	7.5	0.0	136	220																		
23	6.3*																							

* In the mud † Surface of mud

TABLE VI

SUMMARY OF SEASONAL VARIATION OF PHYSICO-CHEMICAL FACTORS IN DOUGLAS, LANCASTER, VINCENT, AND MUNROE LAKES, 1926–33

Locality	Date	Temperature			Thermocline		pH			Oxygen c c per liter			Free CO_2 p p m			M O alkalinity p p.m		
		S	U L H	B	Limits in meters	Fall in temp	S	U L H	B	S	U L H	B	S	U L H	B	S	U L H	B
Douglas Lake South Fish Tail Depression	1926 August 3	22.5	9.8	7.5	14–19	7.2	8.4	7.2	7.1	5.1	0.1	0.0	0.0	8.0	16.0	123	130	133
	1927 July 27	21.2	11.5	10.9	12–18	8.0	8.4	7.1	7.1	5.6	0.0	0.0	0.0	8.0	13.0	117	123	127
	1928 July 21	21.7	12.2	9.9	11–17	8.3	8.0	7.1	6.9	5.4	0.19	0.0	0.0	7.0	15.0	111	122	124
	1929 July 9	19.4	11.8	8.8	12–15	5.8	8.3	7.4	7.0	6.0	3.6	0.03	0.0	4.0	8.0	121	124	126
	1930 July 19	20.2	11.5	9.2	12–17	7.9	8.3	7.1	7.0	6.0	0.7	0.0	0.0	5.0	10.0	125	129	130
	October 18	12.2	n.s	11.6	n.s.	n.s	8.0	n.s	8.0	7.6	n.s	7.6	0.0	n.s	2.5	129	n.s	130
	1931 April 15	3.8	n.s.	3.6	n.s.	n.s	7.4	n.s	7.3	6.0	n.s	5.9	3.0	n.s	3.0	126	n.s	130
	July 27	23.4	8.9	6.8	11–16	11.7	8.3	7.0	7.0	6.0	0.3	0.0	0.0	8.0	10.0	127	132	133
	1932 July 6	20.0	9.8	8.1	11–16	9.0	8.4	7.4	7.0	5.9	1.4	0.0	0.0	2.5	10.0	128	139	141
	1933 July 21	24.0	10.4	8.0	9–16	10.9	8.4	7.3	7.1	5.7	1.3	0.0	0.0	6.0	8.0	129	131	132
	November 5	5.8	n.s.	5.8	n.s	n.s	8.1	n.s	8.1	8.2	n.s	7.5	0.0	n.s	0.0	136	n.s	136
Lancaster Lake center	1926 August 25	22.3	7.5	5.5	2–6	12.7	8.4	7.3	7.3	6.6	0.4	0.0	0.0	13.5	23.0	127	181	209
	1932 August 6	23.5	?	5.3	?	?	8.2	?	7.2	5.6	?	0.0	0.0	?	14.0	150	?	200
	1933 July 10	25.4	9.7	5.3	1–5	15.7	8.3	7.3	7.2	4.9	2.2	0.0	0.0	5.0	10.0	150	152	205
	July 31	26.4	8.8	5.6	2–6	17.4	8.5	7.2	7.2	5.6	1.1	0.0	0.0	8.0	12.0	146	150	209
	November 4	6.6	n.s.	6.2	n.s.	n.s	7.6	n.s.	7.5	5.9	n.s	4.9	5.0	n.s	5.0	166	n.s.	175

TABLE VI (*Continued*)

Locality	Date	Temperature S	Temperature U.L.H	Temperature B	Thermocline Limits in meters	Thermocline Fall in temp	pH S	pH U.L.H	pH B	Oxygen c c per liter S	Oxygen c c per liter U.L.H	Oxygen c c per liter B	Free CO_2 p p m S	Free CO_2 p p m U.L.H	Free CO_2 p p m B	M O alkalinity p p.m S	M O alkalinity p p.m U.L.H	M O alkalinity p p.m B
Vincent Lakes center	1926																	
	July 30	25.1	n.s.	15.5	n.s.	n.s.	6.6	n.s	6.6	6.5	n.s	5.6	1.0	n.s	3.5	6.0	n.s	7.0
	August 25	19.6	n.s	19.8	n.s	n.s	7.0	n.s	7.0	6.8	n.s	7.0	0.75	n.s	7.0	3.3	n.s	6.3
	1927																	
	August 3	20.8	n.s.	19.8	n.s	n.s	6.4	n.s	6.2	5.9	n.s.	5.2	2.0	n.s	4.0	3.0	n.s	4.0
	1928																	
	August 1	21.5	n.s.	21.0	n.s	n.s.	6.3	n.s	6.2	5.0	n.s	5.0	3.0	n.s	4.0	11.0	n.s	11.0
	October 20	12.2					6.1			6.9			2.0					
	1929																	
	July 26	24.6	n.s.	22.8	n.s	n.s.	6.6	n.s	6.1	6.1	n.s	5.3	1.5	n.s	13.0	5.0	n.s	6.0
	1931																	
	April 16	9.0	n.s	9.0	n.s.	n.s	6.0	n.s	6.0	6.0	n	6.1	3.0	n.s	3.0	6.0	n.s	6.0
	July 28	26.0	n.s	21.8	n.s	n.s	6.6	n.s	6.6	6.0	n.s.	5.6	0.5	n.s	3.0	4.0	n.s.	5.0
	1932																	
	July 27	23.5	n.s	22.6	n.s	n.s	5.7	n.s	5.7	5.9	n.s	5.2	2.5	n.s	3.0	10.0	n.s	10.0
	1933																	
	July 28	24.3	n.s	23.9	n.s	n.s	5.8	n.s	5.4	5.4	n.s	4.1	2.0	n.s	5.0	11.0	n.s.	12.0
	November 4	5.4	n.s	7.2	n.s	n.s	6.2	n.s	6.2	8.1	n.s	7.8	2.0	n.s	2.0	8.0	n.s	8.0
Munro Lake	1926																	
	July 29	22.8	n.s	22.7	n.s	n.s	8.4	n.s.	8.2	6.0	n.s	5.7	0.0	n.s.	0.0	112	n.s	115
	1928																	
	August 11	25.3	n.s.	24.5	n.s.	n.s	8.2	n.s	8.2	6.1	n.s	6.3	0.0	n.s	0.0	100	n.s	101
	1929																	
	June 25	25.5	n.s	25.2	n.s.	n.s	8.3	n.s	8.3	6.0	n.s	5.9	0.0	n.s	0.0			
	1931																	
	April 16	7.8	n.s	7.8	n.s	n.s	8.0	n.s	8.0	6.1	n.s	6.0	0.0	n.s	0.0	110	n.s	110
	August 20	23.3	n.s.	22.2	n.s	n.s	8.5	n.s	8.5	6.0	n.s.	5.9	0.0	n.s	0.0	103	n.s	102
	1932																	
	July 20	27.0	25.1	24.4	0–1	1.9	8.4	8.4	8.3	6.0	6.0	5.6	0.0	0.0	0.0	125	126	124
	1933																	
	August 3	24.5	n.s.	23.4	n.s	n.s.	8.5	n.s	8.3	6.0	n.s	5.8	0.0	n.s	0.0	118	n.s.	116
	November 4	3.6	n.s.	3.6	n.s	n.s	7.8	n.s	7.8	8.5	n.s	8.3	2.0	n.s	2.0	104	n.s	104

TABLE VII

DEPTH DISTRIBUTION OF BOTTOM FAUNA IN DOUGLAS, LANCASTER, VINCENT, AND MUNRO LAKES

Locality	Date	Depth in meters	Number of samples	Number of individuals per square meter: Corethra	Chironomus	Protenthes	Tubificidae	Sphaeriidae	All others	Total
Douglas Lake South Fish-Tail depression	1933 August 14	9	3	0	30	0	0	14	14	58
		10.5	3	0	60	30	0	0	0	90
		12	2	58	156	246	388	22	20	890
		13	3	267	633	400	581	89	0	1970
		14	5	722	225	223	445	27	23	1665
		15	3	425	158	132	210	10	0	935
		18	6	465	40	30	133	0	0	668
		22	5	65	30	0	30	10	0	135
		23	5	30	0	0	18	0	0	48
Lancaster Lake	1933 August 10	2	1	0	180	0	268	268	6585	7300
		3	1	0	180	45	356	135	308	1024
		4	1	87	180	45	490	178	0	980
		6	5	668	155	88	1200	176	0	2287
		8	2	535	0	0	1070	0	20	1625
		12	1	178	0	0	178	44	0	400
		16	5	38	0	0	9	15	0	62
Vincent Lake	1933 August 7	1	5	0	175	52	133	83	20	463
		2	5	250	45	40	18	27	12	392
		3	5	18	0	0	27	0	0	45
		4	5	0	0	0	0	0	0	0
Munro Lake Station 50	1933 August 3	0.5	3	0	60	44	30	1023	133	1290
		1	5	290	20	0	20	845	222	1397
		2	5	252	38	0	0	200	0	490
		3	5	330	9	0	0	79	0	418

TABLE VIII

DEPTH DISTRIBUTION OF BOTTOM FAUNA IN DOUGLAS, LANCASTER VINCENT AND MUNRO LAKES

Locality	Date	Depth in meters	Number of samples	Number of individuals per square meter						
				Corethra	Chironomus	Protenthes	Tubificidae	Sphaeridae	All others	Total
Douglas Lake South Fish-Tail depression	1933 Nov 5	10	5	0	19	10	0	0	9	38
		12	1	0	90	0	45	0	0	135
		14	1	801	134	222	267	89	267	1780
		15	1	1246	400	268	45	0	1691	3650
		16	2	1357	445	356	665	45	917	3785
		18	2	1000	178	200	1350	0	45	2715
		20	2	4475	0	0	25	0	0	4500
		21	2	6800	68	0	311	22	0	7200
		22 25	5	6505	68	0	147	45	0	6765
Lancaster Lake	1933 Nov 4	4	2	90	133	44	45	90	8	410
		7	2	156	90	0	45	67	358	825
		11	2	1113	268	0	134	0	0	1515
		13	2	2348	20	0	667	0	0	3035
		15	2	1600	20	0	235	0	0	1855
		16	2	1600	0	0	22	0	0	1622
		17	2	1825	0	0	0	0	0	1825
Vincent Lake	1933 Nov 4	2 5	5	356	45	50	20	35	90	596
		5 0	2	180	89	25	0	0	0	294
Munro Lake Station 42	1933 Nov 4	1 0	1	0	290	89	9	560	1832	2780
		1 5	1	0	400	135	45	800	2670	4005

TABLE IX

DEPTH DISTRIBUTION OF BOTTOM FAUNA IN DOUGLAS LAKE

Locality	Date	Depth in meters	Number of samples	Number of individuals per square meter						
				Corethra	Chironomus	Protenthes	Tubificidae	Sphaeriidae	All others	Total
Douglas Lake South Fish-Tail depression	1931 April 15–16	8	3	0	0	0	0	10	90	100
		9	3	0	0	0	0	0	135	135
		10	3	0	9	18	0	44	22	93
		12	5	89	20	90	133	90	45	467
		14	5	400	445	138	270	90	0	1343
		18	5	1246	135	10	468	22	0	1881
		20	5	3560	90	0	180	0	0	3830
		22	5	4400	40	0	90	22	0	4552
	1931 July 9	9	5	0	10	0	0	44	89	143
		10	5	0	45	9	0	10	30	94
		12	5	135	225	45	9	89	9	512
		15	10	685	178	66	135	20	41	1125
		20	5	180	90	0	178	0	0	448
		22	2	135	22	0	60	0	0	217

TABLE X

OCCURRENCE OF BOTTOM FAUNA IN LANCASTER, VINCENT, AND MUNRO LAKES

Locality	Date	Depth in meters	Number of samples	Number of individuals per square meter								
				Corethra	Chironomus	Protenthes	Tubificidae	Sphaeriidae			All others	Total
								Pis	Mus	Sph		
Lancaster Lake	1926 August 25	16 5	5	29	0	0	10	10	0	0	0	49
Vincent Lake	1926 July 30	2	10	196	31	40	9	18	0	0	9	303
		5	5	0	0	0	0	0	0	0	0	0
		7	10	0	5 (dead)	0	0	0	0	0	0	0
	August 25	1	5	54	125	71	0	480	0	0	80	810
	1927 July 21	1	5	72	80	27	0	436	0	0	107	722
		7	5	0	0	0	0	0	0	0	0	0
Munro Lake	1926 July 29	2.5	5	180	10	0	0	90	0	0	0	280
		1	5	0	27	18	45	80	27	0	249	446

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A LOCAL STUDY OF THE OPISTHOGLYPH SNAKE *TANTILLA GRACILIS* BAIRD AND GIRARD *

EDITH R FORCE

THE little brown snake, *Tantilla gracilis* Baird & Girard, has been called tantilla (Pl XCIX, Fig 1), graceful tantilla, slender, black-headed or miter snake, and sand snake Although it is an opisthoglyph, it may be regarded as harmless to man, for its fangs are very small and posterior in position, it never offers to bite when handled, and nothing seems to be known of its poison

It ranges from "Central Missouri and eastern Kansas, south through Arkansas, Oklahoma, and Texas" (2) In Oklahoma it is apparently restricted to the eastern and southern part of the state It has been taken in Carter County (7), in the Sandstone Hills region, in Le Flore County, in the southeastern Prairie Plains region, and in Okmulgee (14), Creek (7), and Tulsa (11, 14) counties bordering the Prairie Plains region and the northeastern Sandstone Hills region (12)

Although commonly thought of as rare, this tantilla is frequently found in Tulsa County Its supposed rarity and the almost complete lack of information about its habits have prompted the present study of it

The work is based principally on collections made by the writer and her students [1] in northeastern Oklahoma from September, 1926, to June, 1932 In this period 499 specimens were secured, of which 289 were males, 200 females, and 10 immature or of undetermined

* Contribution from the Biological Station of the University of Michigan and from the Woodrow Wilson Junior High School, Tulsa, Oklahoma

[1] Generous assistance in provision of local specimens was received from Mr G E Tenney and his students from Mrs A E Gilmore and Isabelle Borders, and from L M Klauber who loaned a collection from Tulsa Facilities were provided through the courtesy of the Board of Education of the city of Tulsa, Oklahoma The work was suggested by Dr F N Blanchard of the University of Michigan and was furthered by him at many points in its progress

sex In addition, the writer has examined 117 specimens, kindly furnished by Byron C Marshall and R M Perkins, from Lawrence and Pulaski counties, Arkansas Eighty-six specimens from Cowley County, Kansas, were loaned by Dr Charles E Burt Since the specimens received from Arkansas were found under similar conditions and showed the same variations as those from northeastern Oklahoma, they are considered with the Oklahoma specimens Those from Kansas are discussed separately, except as otherwise stated

The general habitat of *Tantilla gracilis* is of a wooded, rocky nature In Tulsa County and vicinity it has been procured from many local areas such as Lost City Mountain, Bald Hill, Parthenia Park, Shell Creek, Osage Hills, and Concharty Mountain The snakes collected in both Oklahoma and Arkansas have been found, without exception, singly and in two's in the moist soil under limestone rocks, along creek banks, on wooded slopes, or along sandy roadsides The size of the rocks seems immaterial, if the soil underneath is not dry The writer has never found a tantilla in the open This may be due to its burrowing habits and preference for the dark, or perhaps to its diminutive size and inconspicuous coloration

This secretive little snake has seldom been mentioned in herpetological literature except in local lists Cope (9) gave a description and a few localities in 1900 A figure of this species was published by Ditmars (10) in 1907 Four years later Hurter (13) stated that it was "common in the Ozark Plateau in Jefferson County," but recorded it only once from St Louis, Missouri [3] He mentioned that it was found mostly under rocks with southwestern exposure In 1926 Strecker (16) gave a short account of his personal collections in Texas and Missouri, dating back to 1893 He found snakes in rocky localities, along the crests of limestone creek beds, under rocks embedded in earth on the sides of the road, under rotted logs along the steep bank of a creek, and under fallen branches on an oak flat at an elevation of a trifle under 400 feet Of three others he said "These were collected in the morning after a heavy rain had driven them from their burrows and they were temporarily housed under great sheets of tar paper " Burt (6) remarks of specimens found in Riley County, Kansas "These sand-snakes are often found under hillside rocks in the loose soil and are very abundant in the spring months "

[3] Mr R M Perkins stated to the writer in June, 1932, that occasionally one or two are found in the vicinity of St Louis

Again, in references to collections from the western half of the United States, he has reported "two sand-snakes on a flat, elevated, grassy plain under rocks in the vicinity of Little Bear Mound at Neodesha, Wilson County, Kansas" (8) They were in the dampest situation possible, specimens were not found under rocks where the soil was very dry Perkins (15), reporting on collections made near Little Rock, Arkansas, in April, 1928, states "Tantillas were very numerous after rain on the rocky ridge with southern exposure" None were found in the open

Mr Marshall, in correspondence regarding *Tantilla gracilis* in Arkansas (Nov 4, 1929), agreed with these findings He also said "The majority of individuals are taken after the rains in April and May Only a few are found in March and June, practically none in July, August, or September, but occasionally a few may be taken in October or early November if it is rainy during this season" The investigations of the writer confirm these findings for northeastern Oklahoma

When the rocks are turned the tantillas quickly slip into the loose, sandy soil If retrieved, they hide in the palm of the hand and burrow between the fingers with a remarkably strong movement of the head They make no attempt to open the mouth In captivity they usually remain hidden, day and night, under the water pan, rock, or board, in rotted wood, or sawdust When a light is suddenly flashed into the cage at night, although sometimes they may be found drinking, they hastily glide away

The food habits of the tantillas would place this species in the class of economically helpful snakes Hurter (13) has said that they feed upon insects Strecker (16) has stated that "while their food consists mostly of insects they do not disdain sowbugs nor an occasional young specimen of a native slug" Blanchard has stated in a letter that one specimen sent him by the writer, May 31, 1926, ate a scarabaeid beetle larva In captivity the tantillas were observed by the writer eating small centipedes, small wireworms, and soft-bodied larvae of the Tenebrionidae (the darkling beetles) and Pyrochroidae, both kinds of which are found in rotted logs Once a small earthworm was taken Millipedes, spiders, sowbugs, slugs, such insects as large wireworms, ants, small adult beetles, and other small forms found in insect sweepings were offered, but are not known to have been eaten

The stomach contents of 73 specimens were examined Although in 10 of these the remains were digested beyond recognition, it is safe to say that enough undigested material was available from the others to establish beyond a doubt the character of the food Dr H B Hungerford, who kindly made the identifications, states that "normal food of the *Tantilla gracilis* is apparently centipedes and earth-dwelling insect larvae such as cutworms, wireworms, and leatherjackets (larvae of the Tipulidae or crane-flies)" In addition, certain fungus grubs, larvae of the Mycetophilidae, were in the stomach contents of the young Very frequently undigested nematodes were among the digested remains These have been identified, through the courtesy of Dr Lyell J Thomas, as Oxyuridae of beetles and centipedes

There is apparently no record of the mating habits of these snakes Marshall surmises that, since they are so evident in the rocky hillsides in April and May, "they must breed early in the spring, however, this is a guess and not substantiated by any personal observation or evidence" Mr Marshall's surmise may be correct, or the snakes may be above ground merely because it is too wet for life below at this season Or it may be that one of their favorite foods, the meadow maggot or leatherjacket, which is known to come to the surface of the ground during the night, is the cause Observations made by the writer on the size of the gonads of tantillas collected in practically every week from the middle of February until the first of June indicate May as the time of mating

The males of mature size, i e 174 mm or longer, collected in Oklahoma between May 1 and June 1, had well developed testes, 5 to 9 mm long Earlier in the spring they are much smaller Females collected before May 1 had ova 0 5 to 5 0 mm in length Those collected on May 20 showed ova 5, 7, 9, and 21 mm in length as well as others of microscopic size No mature female (i e over 190 mm) collected before May 10 had deposited eggs, whereas six females of this size collected on May 20, 24, and 28 had laid These data, together with the information previously noted concerning the time of greatest activity of both male and female in the field, make it seem probable that the first half of May may be the usual time of mating It is an interesting fact, possibly related in some way to mating activities, that in March and May from two to three times as many males as females are found, whereas in April the females are twice as numerous as the males

PLATE XCIX

FIG. 1. *Tantilla gracilis* Baird & Girard (photograph by H. K. Gloyd).

FIG. 2. Two sets of eggs of three each of *Tantilla gracilis* Baird & Girard, deposited June 13 and 19, 1932 (photograph by Dr. F. N. Blanchard).

Several years ago this species was judged by Strecker (16) to be oviparous, because he found in San Antonio, Texas, three small reptilian eggs under the same rock with a tantilla. The eggs were crushed in the turning of the stone, so that they could not be hatched for identification. Proof of the oviparity was furnished by the writer in 1928. Since then dissection of 265 females, 10 of which had laid eggs, has shown that the most common numbers in a set are 2 and 3. Complements of 1 and 4 have been noted in some cases. Deposition

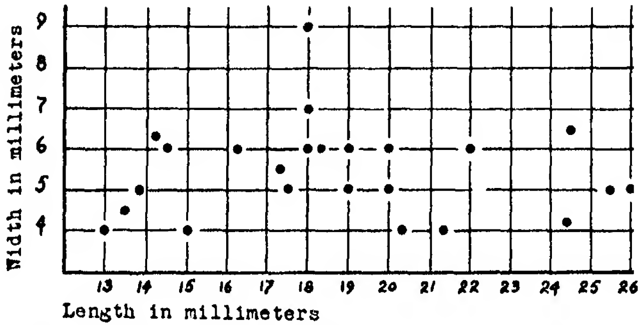

FIG 52. Dimensions of eggs of *Tantilla gracilis* Baird & Girard laid or ready for deposition. Each dot represents one egg.

of the eggs has not been seen, the eggs have always been discovered in the morning in the moistest part of the cage, even in the water pan.

The eggs are laid from the middle of June to about the middle of July. June 13 is the earliest date noted for a set of normal eggs of females collected in Oklahoma. Other dates recorded are June 18, 19, 22, 25, and 26. Marshall, however, reported (Nov. 4, 1929) a set laid on July 9. One set of abnormal eggs was laid on July 8 and 11. These records of egg-laying are all from females collected after May 20. In seven females collected between July 1 and 3, 1928, the anterior oviduct looked as if eggs had recently been deposited.

The variation in dimensions of the eggs when laid, given in an earlier study (11) as from 15 to 24 mm. in length and from 4.2 to 6.5 mm. in width, has been extended by further measurements to from 13 to 26 mm. in length and from 4.2 to 9 mm. in width (Pl. XCIX, Fig. 2, text Fig. 52).

The date of hatching has been obtained for a few eggs laid by

females that had been transported to northern Michigan Such eggs, kept in the laboratory, surrounded by damp, rotted wood, hatched September 17 (1930) and September 7 and 14 (1932) The lengths of the periods from laying to hatching were 83 and 84 days If, as is likely, the eggs are laid earlier under natural conditions, the

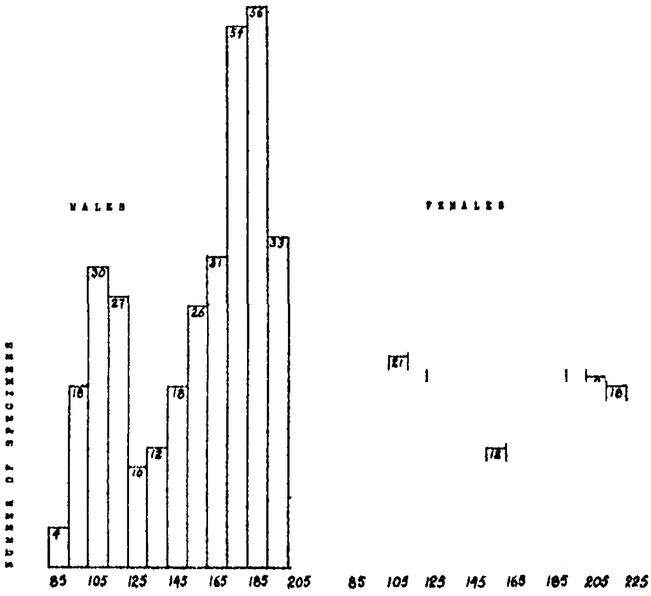

Fig 53 Total lengths of males and females of *Tantilla gracilis* Baird & Girard The lengths of females observed to lay eggs or to contain eggs ready for deposition are represented by black dots

hatching time in Oklahoma is probably earlier than September 1 Furthermore, Oklahoma's warmer climate as compared with northern Michigan should hasten the hatching

The young snakes emerged from the eggs in about one day after slitting the shell (in the two instances observed) Two young, measured at birth, were 77 5 and 92 0 mm, in total length [8]

[8] Thanks are due to Dr Blanchard, who cared for these eggs after August 20 and furnished this report

Size in this species seems to be limited to a maximum of about 230 mm. and a minimum of about 77 mm. Two hundred and ten females varied from 90 to 230 mm. and 324 males from 85 to 205 mm. (Fig. 53). The females thus attain a definitely larger size than the males. When the lengths of all these specimens are plotted in a diagram each sex is seen to be composed of two groups. The smaller group of younger individuals is obviously composed of those hatched in the preceding season. The large group, containing the longest individuals, includes the adults, but not all in this group are adult. The size for adult females ranges from 190 to 230 mm. (See Fig. 53.)

It is perhaps questionable whether it is profitable to attempt to locate age groups between the yearlings and the adults, but dissections of females of all sizes seemed to furnish evidence on this point. In females from 90 to 125 mm. in total length the ova were of microscopic size. This is the yearling group. In females from about 125 to 155 mm. there was a noticeable development of the ova in size, color, and form. The ova measured 1 to 2 mm. in length and were creamy white, firm, and elongated. Eggs from snakes of approximately 185 mm. are of two sizes, or even three in larger specimens (adults). They vary in length from 0.1 to 4.0 mm. and in width from 0.1 to 2.0 mm. There are 8 to 16 eggs in each ovary. Females longer than 185 mm. have reached maturity, to judge from the appearance and size of the ova (Table I).

TABLE I

RELATION OF TOTAL LENGTH TO SEXUAL MATURITY IN 176 FEMALES

Age-groups	Lengths in mm	Remarks
Juveniles	85–125	Probably born in August, collected the following spring. Ova microscopic
Young	125–185	Probably about one to one and one-half years of age
	(125–145)	Ova variable in size
	(145–155)	Ova 1–2 mm., white to creamy, flabby, round
	(155–185)	Ova 2–4 mm. in length by 0.1–2.0 mm. in width, becoming firm and elongate. Some individuals may be mature
Adults	185–230	Probably one and one-half to two and one-half years of age. An occasional one contained egg clusters for deposition the next year. Eggs mature at 191, 195, 196, 198, 205, 210, 215 (3), 227, 230 mm.

Dissection of the males reveals a similar relationship between size and appearance of the gonads and length and maturity of the snake Fresh specimens showed a marked difference in the size and appearance of the testes in the smaller and larger males In those from 155 to 175 mm in length there was a gradual change from a flabby, white immature organ to a firm, elongate, yellowish, apparently mature testis Although probably only the largest of this group were of reproductive size and age, those of 185 mm and over were beyond a doubt adults (Table II)

TABLE II

RELATION OF TOTAL LENGTH TO SEXUAL MATURITY IN 215 MALES

Age-groups	Lengths in mm	Remarks
Juveniles	85–125	Probably born in August, collected the following spring Testes immature
Young	125–175	Probably about one to one and one-half years of age
	(125–155)	Testes becoming mature
	(155 175)	Testes 4 5–6 5 mm
Adults	175-205	Probably one and one half to two and one-half years of age
	(175 185)	Some snakes mature
	(185–205)	All mature Testes about 4–8 mm in length

A clearer definition of the age-groups may be obtained from a single collection of 59 individuals found between April 1 and 15, 1932 The total lengths of all individuals with complete tails, 53 in number (31 males and 22 females), ranged from 90 to 205 mm There are two well-defined groups, juveniles and adults, with an intermediate group of less definite range It would appear that the smallest individuals, those from 95 to 125 mm, were the young of the previous season, and that 115 mm is their average length They are in their first full season of growth These may be called the yearlings The individuals of greater size, presumably more nearly mature, ranging from 135 to 175 mm, may be in their second year These are approaching maturity and are possibly in the beginning of their third season of growth Full maturity is likely to be reached in their fourth season, at 185 to 195 mm In other words, these snakes are apparently of a size and age to deposit eggs when about two and one-half years old It thus appears that both sexes mature at approximately the same age, the males at a length of about 175 mm, and the females at 185 mm

"In its coloration, *Tantilla gracilis* is rather variable," says Strecker (16) "Of specimens collected in the northern part of its territory the upper surfaces are either reddish or plumbeous, of those from northeastern Texas they are brown, while of those from Waco and south of San Antonio, they are golden-brown There is also considerable variation in the amount of red on the lower surfaces and in the color of the head plates" Specimens from northeastern Oklahoma seem best to match Strecker's specimens from northeastern Texas The five hundred examples examined by the writer conform closely, except in degree of color, with the description previously given, gray-brown to a rich red-brown, with the head a little darker, below, varying shades of salmon pink, except under the chin and the anterior end of the body and the ends of the ventrals, which are white (11) In alcoholic specimens, in which the pink color has been destroyed, there is frequently observed pigmentation on the lateral edges of the anterior half of the ventrals This does not show so plainly when the color is visible

The squamation is apparently uniform in this species There are 15 smooth scales the entire length of the body In 616 specimens only a very few, i e 12 females and 28 males, show variation from the formula of 6 supralabials and 6 infralabials (Table III) The oculars

TABLE III

NUMBERS AND KINDS OF VARIATIONS FROM THE USUAL ARRANGEMENT OF LABIAL SCUTES (6 ABOVE AND 6 BELOW)

Supralabials

	Number of males	Number of females
6 left and 5 right	6	4
5 left and 6 right	10	0
7 left and 6 right	2	1
7 left and 8 right	0	1
Total	18	6

Infralabials

	Number of males	Number of females
6 left and 5 right	3	6
5 left and 6 right	6	0
7 left and 6 right	1	0
Total	10	6

in the Oklahoma specimens proved to be invariably one before the eye and one behind Two females from Arkansas, however, showed these arrangements 2 1 left, 2–2 right, and 1–1 left, 2–1 right The temporals are uniformly 1 anterior and 1 posterior There is no loreal The anal plate is always divided

The proportionate length of the tail, i e the tail length divided by the total length, is different in the two sexes, as is usual in snakes (Table IV) In the males the tail varies from 16 to 30 per cent of the total length, and in the females from 14 to 27 per cent Thus the range for the species as represented by the Oklahoma and Arkansas specimens is from 14 to 30 per cent But the difference between the sexes is really larger than these figures show, for in the great majority of the males examined the tail is more than 20 per cent of the total length, and in all but three of the females it is less than 25 per cent Data of all specimens examined are summarized in Table IV

TABLE IV

LENGTH OF THE TAIL IN PROPORTION TO TOTAL LENGTH

13 1–14 0	0	1
14.1–15 0	0	1
15 1–16 0	1	0
16 1–17 0	4	5
17 1–18 0	2	5
18 1–19 0	5	21
19 1–20 0	2	35
20 1–21 0	14	38
21 1–22 0	33	46
22 1–23 0	43	19
23 1–24 0	87	10
24 1–25 0	67	1
25 1–26 0	37	1
26 1–27 0	17	1
27 1–28 0	4	0
28 1–29 0	2	0
29 1–30 0	2	0
Total	320	184

The caudals vary in the females from 36 to 48, and in the males from 44 to 57 (Fig 54) The ventrals range in the females from 126 to 138 and in the males from 115 to 127 (Fig 55) It will be noted

that the overlap between the sexes in the counts of caudals and ventrals is small, in the first case it involves only those with 46 to 48 caudals, in the other it involves only those with 126 and 127 ventrals

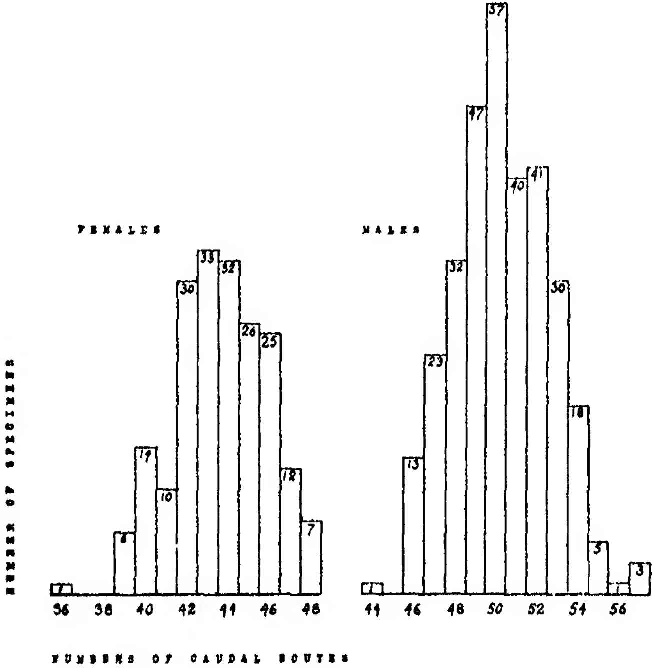

FIG 54 Numbers of caudal scutes in females and males of *Tantilla gracilis* Baird & Girard

We may take advantage of the difference between the sexes in the counts of ventrals and caudals to determine the sex of a specimen from scale counts alone If the number of caudals is subtracted from the number of ventrals, the differences between the sexes are accentuated The reason for this is that in the males the higher number of caudals is subtracted from the lower number of ventrals, whereas in the females the smaller number of caudals is subtracted

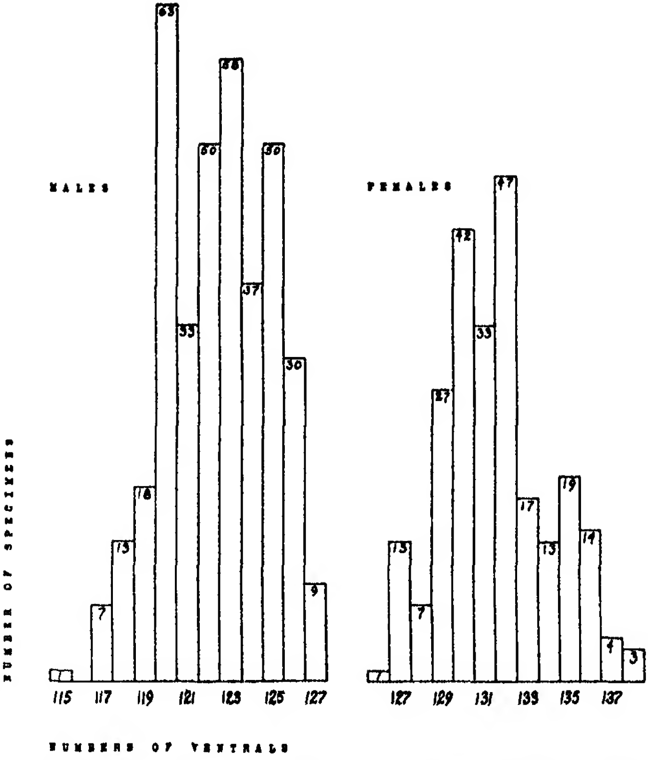

Fig 55 Numbers of ventral scutes in males and females of *Tantilla gracilis* Baird & Girard

from the larger number of ventrals If we designate this computation as v–c,[4] and apply it to this species, it appears that a specimen in which v–c is less than 80 is a male and that one which is 82 or more is a female (Fig 56)

It is evident that sex in *Tantilla gracilis* may be determined with

[4] This method of combining the ventral and caudal counts for determination of sex is taken from Dr F N Blanchard's study of the genus *Diadophis* (*in manuscript*)

considerable assurance of accuracy from the caudal and ventral counts alone, when the tail is complete at the tip (Figs 54–55) When the tail is incomplete, the ventrals alone will in a great majority of cases be sufficient

It is of interest to note that in total length, proportionate length of tail, ventrals, caudals, and ventrals minus caudals the 86 speci-

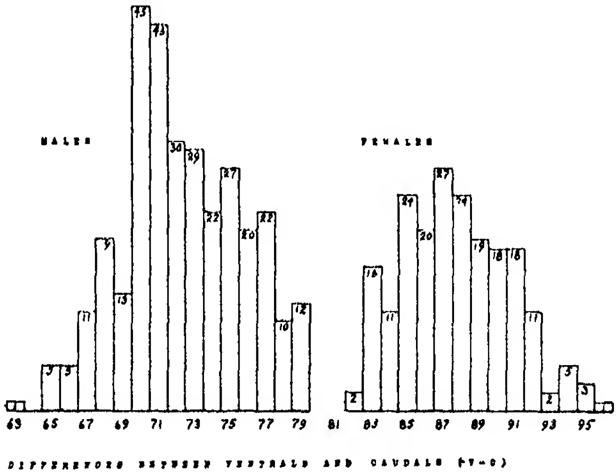

FIG 56 Relation of the differences between ventrals and caudals (v–c) of males and females in *Tantilla gracilis* Baird & Girard

mens from Cowley County, Kansas, show no variation beyond the limits of the Oklahoma and Arkansas material The result of plotting the Kansas specimens on the basis of ventrals minus caudals is to divide it into two groups, one in which v–c is 68 to 78 and the other in which it is 83 to 93 That this correctly distinguishes the sexes of these specimens is wholly probable

SUMMARY

Tantilla gracilis is a common snake in the wooded, rocky country of northeastern Oklahoma It has been relatively little collected, owing to its diminutive size and secretive habits Specimens are

most often and easily collected after the spring rains, usually in April and May

The food of this species has been shown to comprise centipedes and earth-dwelling insect larvae, such as cutworms, wireworms, and crane-fly larvae Fungus grubs (larvae of the Mycetophilidae) were found in the stomachs of the young snakes

The first half of May is indicated as the probable mating season

Eggs, one to four to a complement, have been deposited in June and early July, in the laboratory They vary from 13 to 36 mm in length and from 4 to 6 5 mm in width

Eggs kept in the laboratory have hatched on September 7, 14, and 17

The total length varies in this species from 85 to 230 mm The females grow to a distinctly larger size than the males

Some evidence is presented favoring the view that sexual maturity is attained about two and one-half years after birth

The sexes may generally be separated on the counts of ventral and caudal scutes, and may always be when the number of caudals is subtracted from the number of ventrals Thus all examples in which this figure is less than 80 proved to be males, and all those in which it is more than 81, females

The details of scutellation, proportion, and color are given

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SOME ABERRANT COLOR PATTERNS IN SNAKES *

HOWARD K GLOYD

AMONG the various live snakes received from correspondents during the past two years certain specimens of *Elaphe*, *Thamnophis*, and *Crotalus* exhibit unusual aberrations in pattern and general coloration which do not appear to be mentioned in the literature Descriptions of these peculiarities have been prepared, seriatim, because of their general interest as well as for the benefit of future students who will have access to the specimens, but to whom the original colorations would not otherwise be available The most salient deviations from the normal conditions are emphasized by the use of italics

Elaphe laeta (Baird and Girard)

Two specimens of the spotted rat snake (H K G 3002, ♀, 3003, ♂)[1] from San Antonio, Texas, show departure from the normal pattern of the subquadrate blotches on a unicolored ground (Pl C Fig 1) in having the *blotches of the dorsal series either partially or entirely divided along the middorsal line,* often forming H-shaped figures, and the *ground color darkened between the lateral halves of the divided blotches, producing the general effect of two longitudinal stripes* (Pl C, Fig 2) Anteriorly the divided spots become confluent The blotches of the lateral series, which normally alternate with the dorsal, are irregularly broken up and also tend to run together A condition of longitudinal striping involving both ground color and blotch pattern is thus approached

This species is one of the forms of *Elaphe* which have no well-marked ontogenetic change in coloration The ground color and the pattern of the adult are the same as those of the young The two

* Contribution from the Zoölogical Laboratory of the University of Michigan

[1] Catalog numbers with the initials H K G refer to the personal collection of the writer All such specimens, however, are to become the property of the Museum of Zoölogy, University of Michigan

aberrant specimens here described are apparently mature but not unusually large individuals In the snake pens of Texas reptile dealers I have seen numerous examples of this species, much larger than those in question, and have noted no tendency toward striping in presumably much older specimens There is no apparent indication that in this species a pattern of stripes is related to age, nor is it suggested that the condition is prevalent in the Texas region

In contrast to this is the development of the adult coloration in *Elaphe quadrivittata* (Holbrook), the four-lined "chicken snake" of southeastern United States In young individuals of this species the ground color is a uniform gray, upon which is superimposed a pattern of grayish brown blotches These become progressively obsolete with age, and the adult pattern of four brown longitudinal stripes is acquired by a gradual darkening of the ground color (Pl CI, Fig 1) I have observed indications of a similar ontogenetic change in coloration in certain specimens of *Elaphe obsoleta obsoleta* (Say), the pilot blacksnake, and *Elaphe guttata* (Linnaeus), the corn snake Blanchard (1921, pp 118-119, Fig 40) has described and figured a similar phenomenon in one of the king snakes, *Lampropeltis calligaster* (Harlan) It seems, therefore, that the ground color and the pattern in such species are controlled by two independent sets of genetic factors, and that in the genus *Elaphe* a pattern of longitudinal stripes is to be regarded as a recent specialization, secondary in nature, showing up incipiently in *laeta*, *obsoleta*, and *guttata* and reaching its highest degree of development in *quadrivittata*

Thamnophis sauritus proximus (Say)

A ribbon snake collected near Floresville, Texas (H K G 3485, ♂, Pl CI, Fig 2) is remarkable in the possession of *a brilliant red middorsal stripe instead of the usual yellow or greenish yellow* and the presence of *a conspicuous orange line on the midventral surface of the tail* A color description of the entire specimen follows dorsal ground color "olivaceous black",[1] top of head similar but muzzle lighter with slightly more green, occipital spots "pale viridine yellow", anterior tip of middorsal stripe "light green-yellow," remainder of stripe "Morocco red", lateral stripes "light green-yel-

[1] Color names in quotation marks are those of Robert Ridgway, *Color Standards and Color Nomenclature* Published by the author, Washington, 1912.

low", ground color of scale rows 1 and 2 "olive-green", ventral surface anteriorly cream, changing posteriorly to "pale green-yellow", rostral, mental, and anterior labials "light buff", remainder of supralabials "green-yellow", remainder of infralabials, chin shields, and gulars white, a conspicuous, finely stippled, median line of "orange chrome" on the ventral side of tail, from anus to tip

It is quite possible that red-striped individuals are more numerous than published descriptions indicate The various tones of red fade rapidly in formalin and alcohol, and descriptions based largely upon preserved material would be unlikely to include this variation Ruthven's mention of a "rarely reddish, occasionally brown" dorsal stripe in this form (1908, p 98) may refer to such specimens

Crotalus confluentus confluentus (Say)

Nearly twenty-five hundred prairie rattlesnakes were captured in central South Dakota by Mr A M Jackley of Pierre during the seasons of 1932 and 1933 All specimens of unusual coloration, together with several hundred others, were sent to me In the normal coloration of this species in the northern portion of the Great Plains Region the ground color varies from pale brownish gray to greenish gray or grayish green There is a distinct pattern of brownish gray or greenish gray blotches (Pl CII, Fig 1) The degree of contrast between the ground color and the pattern of blotches varies somewhat The proximal crossbands of the tail are of the same color as the blotches of the body, but the distal ones are darker and the two or three immediately preceding the rattle are black The top and the sides of the head are usually prominently marked

One of the aberrant specimens (H K G 3512, ♀, Pl CII, Fig 2) collected in Stanley County, South Dakota, four miles northwest of Van Meter, conspicuously lacks certain features in pigmentation. *The green element in the general coloration is entirely wanting, and the brown pigment of the blotches is much reduced* The dorsal ground color is pale gray, the ventral surface white The blotches of the dorsal series are pale grayish brown, irregular in form, and lack the usual more or less distinct borders The lateral blotches are similar in color, but even less distinct The ventral surface is laterally flecked with light gray

There is no trace of head pattern The pigmentation of the iris is apparently normal The *tongue*, however, instead of being jet black

as is characteristic with this species, *is bright pink with white tips The proximal tail rings have completely disappeared and the terminal rings are blended together forming, with the basal segment of the rattle, a conspicuous black tip The ventro-lateral portion of the tail in the region of the anus is suffused with pale orange*

The only peculiarity in lepidosis is the irregularity of the scales of the muzzle The internasals, usually in contact with the rostral, are separated from it by six small scales (Pl CII, Fig 2) The left side has two loreals, the right, one Total length 500 mm , tail length 30 mm , scale rows 27 27–19, ventrals 180, caudals 20, supralabials 15-15, infralabials 15–15

A very similar specimen collected near Gem, Thomas County, Kansas (No 6549, ♂), in the private collection of Mr L M Klauber, has been examined and compared with the one just described In coloration it much resembles the South Dakota specimen except that the dorsal blotches are more distinct, there is a suggestion of a head pattern, and the tip of the tongue is black No trace of orange is visible in the preserved specimen, but Mr Klauber stated that when fresh a tinge of that color was noticed near some of the blotches The scutellation of the head is much more symmetrical than that of the other, and the four internasals are in direct contact with the rostral Total length 745 mm , tail length 57 mm , scale rows 27–27 21, ventrals 180, caudals 30, supralabials 16–16, infralabials 16–17, loreals 1–1

A few other examples from Sully County, South Dakota, show certain tendencies toward a similar condition One (H K G 3737, ♀) has little or no green in its coloration, although the blotched pattern is distinct The head markings are obscure, the proximal tail bands indistinct, and the distal ones fused into a conspicuous black tip The tongue is black, but spotted with pink Three others (H K G 3384, ♀, 3738, ♀, 3739, ♀) have more or less typical coloration, but black tongues with pink tips Another (H K G 3740, ♂) with normal coloration has the tongue alternately blotched with black and pink

These specimens, it seems, must be regarded as exhibiting tendencies toward albinism That complete albinism has not occurred in those in which the peculiarities described are most manifest is indicated by the fact that the eyes show almost normal pigmentation An impairment or loss of the genetic factors for certain features

of coloration, particularly the greens of the skin pigments, appears to have occurred

Although instances of seemingly true albinism in rattlesnakes have been reported,[3] I know of no records of such occurrences in *Crotalus confluentus confluentus* (Say) I have observed tendencies toward flavescence in specimens from New Mexico and have been told of two cases of melanism in this species Mr W A Bevan of the Witte Memorial Museum, San Antonio, Texas, related having seen a specimen taken in the foothills of the mountains southwest of Fort Collins, Colorado, and Dr E C O'Roke, assistant professor of Forest Zoology, University of Michigan, described a very similar specimen which he saw in the Black Hills region near Spearfish, South Dakota In both these snakes, according to my informants, there was sufficient black pigment to obscure the pattern almost completely

Another prairie rattlesnake obtained by Mr Jackley in Stanley County, South Dakota, twelve miles west of Fort Pierre (H K G 4174, ♂) exhibits an aberration in which *the pattern consists of stripes anteriorly instead of blotches, whereas the ground color seems to be unaffected* (Pl CIII, Fig 1) The top of the head is practically unmarked, but the essential features of the lateral head pattern can be traced The ground color is pale olive gray, lighter on the sides, and pale greenish white on the ventral surface The pigment which normally produces the dorsal series of blotches is arranged in two longitudinal brownish green stripes beginning just back of the occipital region and extending posteriorly for about two fifths of the total length Each stripe is a little more than three scales in width and narrowly outlined with pale greenish white A median stripe of ground color is slightly wider than the middorsal scale row Posterior to the longitudinal stripes are eleven indistinct, irregularly placed blotches of the same color No lateral blotches are present The posterior portion of the body and the proximal two thirds of the tail

[3] Two albino specimens of *Crotalus horridus* Linn collected in the Berkshire Hills near Sheffield, Mass, have been recorded by R I Ditmars, *Twenty-seventh Ann Rep New York Zool Soc* (1923), pp 49 115 This author has also described an albinistic *Crotalus terrificus* (Laurenti) from Managua, Nicaragua, *Ninth Ann Rep New York Zool Soc* (1905), pp 197–200 Several albino individuals of the latter species from the the state of São Paulo, Brazil, have been noted by A do Amaral, *Rev Mus Paulista*, 15 (1927) 56 57, figs 1–3, and *Mem Inst Butantan*, 7 (1932) 82–83, Fig 5

are unmarked, and the black bands of the distal part of the tail are blended together

There are no special peculiarities in the scutellation of this specimen Total length 610 mm , tail length 50 mm , scale rows 25-25-19, ventrals 178, caudals 29, supralabials 15-15, infralabials 14-15

Since evidence obtained in my recent studies suggests that there may have been a striped ancestral stage in the evolution of rattlesnake patterns, I am inclined to regard as atavistic in nature the appearance of a striped pattern in occasional specimens, such as this one and the next one described

Crotalus horridus Linnaeus

In the timber rattlesnake the black chevron-shaped crossbands of the normal pattern are frequently divided in the middle or variously broken up into irregular blotches, which sometimes are confluent in the neck region and have a tendency to form longitudinal stripes A complete rearrangement of the transverse pattern had occurred in an individual of this species which was captured in Franklin County, Pennsylvania, in July, 1933 I was unable to see this specimen, but from a photograph (Pl CIII, Fig 2) furnished by Mr Henry E Clepper of the Pennsylvania Department of Forests and Waters and from some notes and sketches received from Mr J T Rothrock of Pine Grove Furnace, Cumberland County, Pennsylvania, and Mr M Graham Netting of the Carnegie Museum, I learned that *no traces of the transverse bands remained, all of the black pattern having been lost* The seal-brown middorsal stripe which is present in many specimens of this species occupied its usual position on the median row of scales and the inner half of each adjacent row The outer half of each of these rows was of cream color, forming a light border for the median stripe A similar *light-bordered seal-brown stripe was found on each side occupying approximately scale rows 3 to 6, continuous anteriorly but broken up into narrow elongate blotches on the posterior half of the body* The ground color was grayish brown Marked irregularity of pattern is characteristic of this species, but in the several hundred specimens of *C horridus* which I have studied no instance of a color pattern differing so fundamentally from the normal has been encountered

Crotalus lucasensis Van Denburgh

The normal pattern of the San Lucan diamond rattlesnake is characterized by a conspicuous dorsal series of dark brown, diamond-shaped blotches, each of which is sharply outlined by a border of yellowish white scales, and one or two series of smaller and less distinct blotches on each side The top of the head is grayish brown, darker on the muzzle, and with scattered dark brown blotches posteriorly There is a yellowish white spot or dash on each supra-ocular shield A lateral dark brown stripe conspicuously bordered with yellowish white extends from the eye obliquely backward to the mouth The rostral shield is narrowly bordered with white The dorsal ground color ranges from yellowish white to olivaceous, with no minute dark brown or black punctations The ventral surface is cream-colored or yellowish white The tail is grayish white, with four or five transverse black bands

Mr Klauber has kindly permitted me to describe here an abnormal rattlesnake of this species from the Cape Region of Baja California (L M K 2243, ♂) In this specimen *both the ground color and the pattern are unusually pale and nonuniform All the blotches of the pattern are reduced in relative size and, with the exception of a few near the middle of the body, are irregular or almost obsolete* A straggling row of small irregular brown spots is all that remains of the dorsal blotches on the anterior portion of the body Posteriorly the pattern fades out until it is scarcely distinguishable from the ground color Only with the larger and more regular blotches are the yellowish white borders distinctly evident The *top of the head is unmarked save for two small, indistinct brown spots on the muzzle and an irregular, transverse brown patch crossing the occipital region and extending forward above the angle of each jaw* The stripes on the sides of the head are not sharply defined, and the rostral shield lacks white borders The ventral ground color is yellowish white, as in normal specimens The grayish white tail is crossed by five indistinct black bands, some of the pigment of which has encroached in a diffused fashion on the light interspaces

A comparison of this rattlesnake with other material which I have examined and with the diagnostic characters published by Klauber (1930, p 11) reveals no aberrations in structural features Total length 1255 mm, tail length 75 mm, scale rows 32–27–23,

ventrals 194, caudals 26, supralabials 16–16, infralabials 17–18, first pair of infralabials divided transversely, upper preocular narrowly in contact with postnasal

It seems probable that in this specimen, as in some of the *Crotalus confluentus confluentus* (Say) described above, we have a case of partial albinism The loss of normal pigmentation is expressed in both the ground color and the pattern

ACKNOWLEDGMENTS

I am grateful to Mr W A Bevan and Mr R F Harvey of San Antonio, Texas, and Mr A M Jackley of Pierre, South Dakota, for sending the live snakes here described, to Mr L M Klauber of San Diego, California, for the loan of specimens from his private collection and for critical comments on some of the material, to Mr Henry E Clepper of the Pennsylvania Department of Forests and Waters and Mr J T Rothrock of Pine Grove Furnace, Cumberland County, Pennsylvania, for permission to use the photograph reproduced in Plate CIII, Figure 2, and to Dr Frank N Blanchard of the University of Michigan for advice concerning the preparation of this paper

University of Michigan

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Note — All photographs, with the exception of that for Figure 2 of Plate CIII, were made by the author with panchromatic films and a Wratten K-2 yellow filter

PLATE C

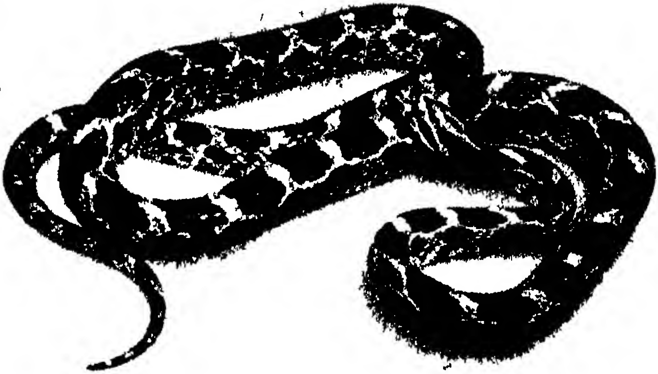


Fig. 1. *Elaphe laeta* (Baird & Girard). Normal color pattern. H. K. C. Ottawa, Kansas.

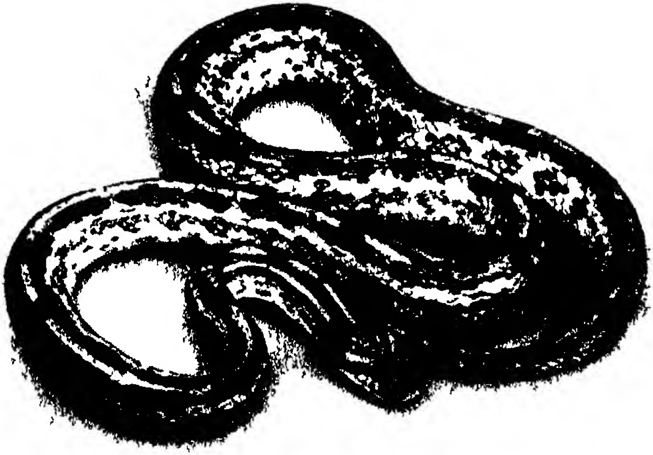


Fig. 2. *Elaphe laeta* (Baird & Girard). Aberrant pattern. H. K. G. 3002. San Antonio, Texas.

PLATE CI

FIG. 1. *Elaphe quadrivittata* (Holbrook) showing adult pattern of longitudinal stripes formed by darkening of the ground color and replacing the juvenal pattern of blotches. H. K. G. 3834. Pine Crest, Florida.

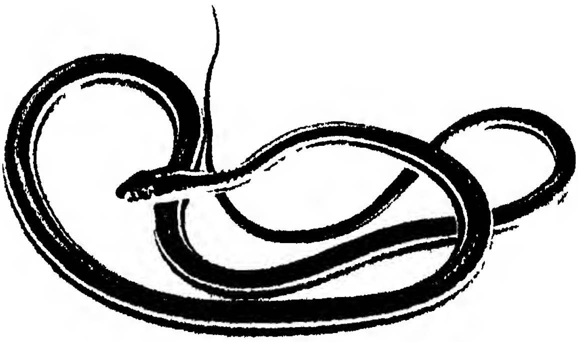


FIG. 2. *Thamnophis sauritus proximus* (Say). A brilliant red middorsal stripe was the chief characteristic of this specimen. H. K. G. 3485. Floresville, Texas.

PLATE CII

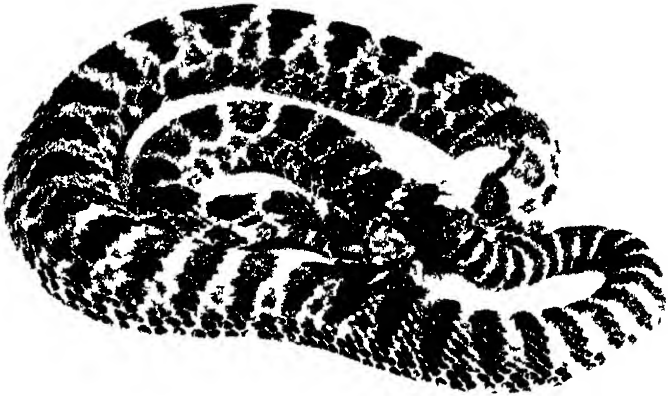


FIG. 1. *Crotalus confluentus confluentus* (Say). Normal coloration. H. K. C. Sully County, South Dakota.

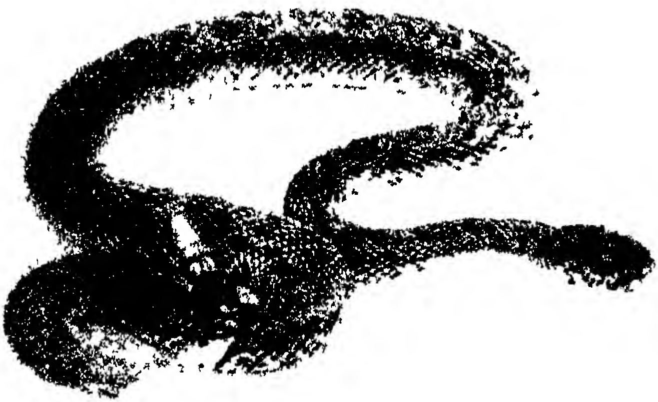


FIG. 2. *Crotalus confluentus confluentus* (Say). Partial albino. H. K. C. 351. Stanley County, South Dakota, four miles northwest of Van Meter.

PLATE CIII

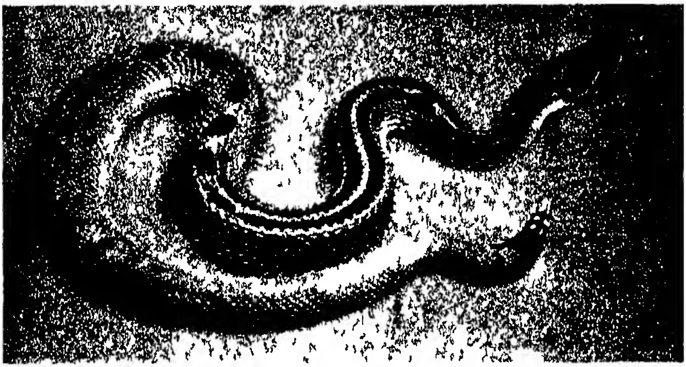


FIG. 1. *Crotalus confluentus confluentus* (Say). An aberrant striped pattern instead of the usual series of blotches. H.K.G. 4174. Stanley County, South Dakota, twelve miles west of Fort Pierre.

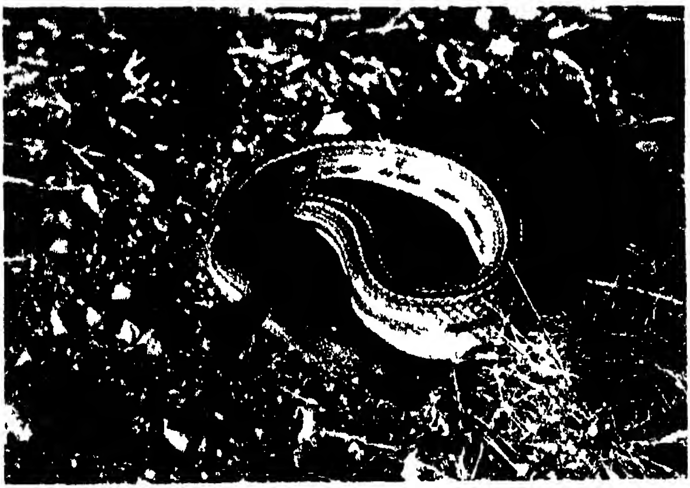


FIG. 2. *Crotalus horridus* Linnaeus. Normal pattern of black cross bands replaced by longitudinal brown stripes. Franklin County, Pennsylvania. Photograph by courtesy of Pennsylvania Department of Forests and Waters.

AGE AND GROWTH OF THE LONG-EARED AND THE GREEN SUNFISHES IN MICHIGAN *

CARL L HUBBS AND GERALD P COOPER

I INTRODUCTION

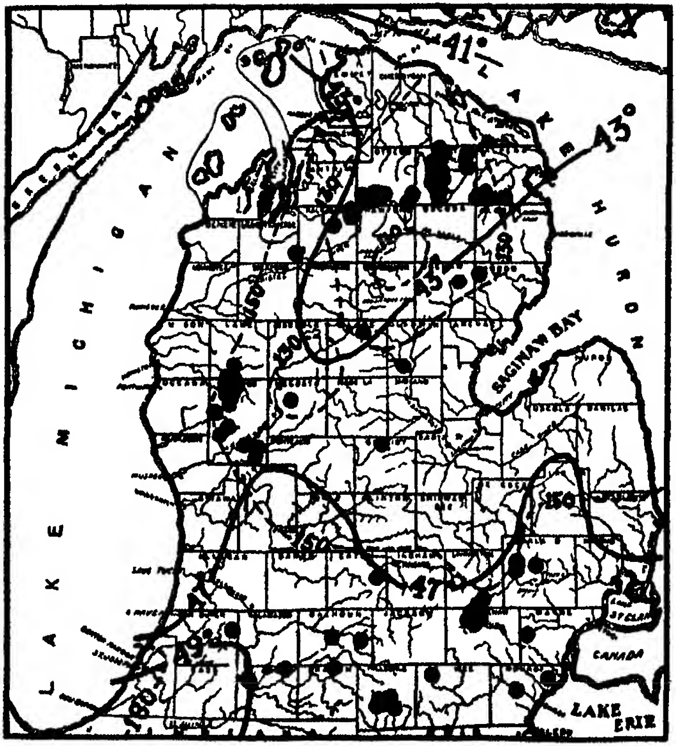
THE investigation reported upon in this paper was undertaken to elucidate several features in the life history in Michigan waters of (1) the dwarfed form of long-eared sunfish, *Xenotis megalotis peltastes*, and (2) the green sunfish, *Apomotis cyanellus* The study has been based on an examination of the scales of 1,129 specimens of the long-eared sunfish representing 79 collections, all from the Lower Peninsula of Michigan, and of 514 individuals of the green sunfish representing 85 collections The distribution of these collections is indicated by Maps 46–47

The methods employed were those now becoming more or less standard in investigations on the life histories of fishes The scales of all specimens, except most of the yearlings in one large collection of the long-eared sunfish, were mounted in glycerine jelly and were examined by aid of a projecting machine The age status of this one group of yearlings was so obvious that only a few scale readings were deemed necessary

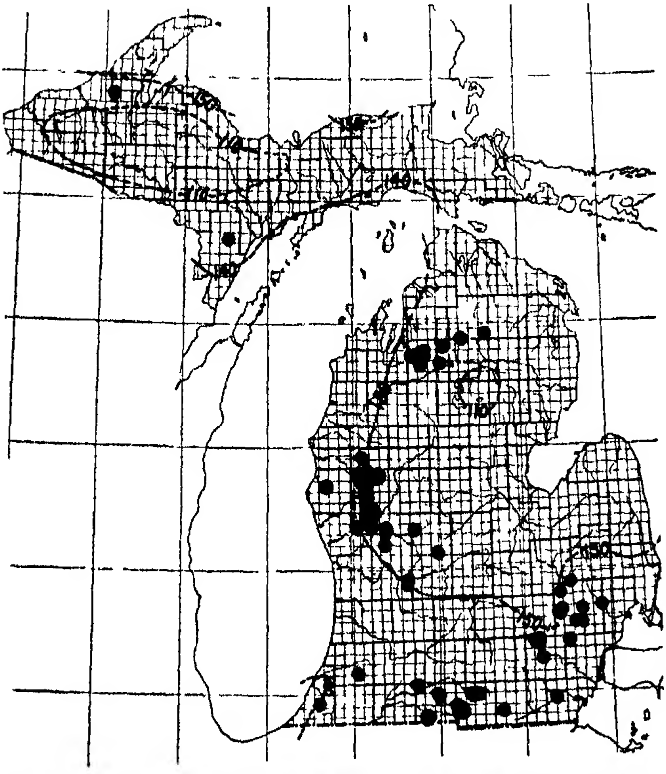
The validity of the scale method for age determination of fishes in the family Centrarchidae, which includes *Xenotis* and *Apomotis*, was demonstrated by Creaser (1926) and has been thoroughly confirmed by the earlier and subsequent researches of Barney and Anson (1923), Potter (1925), Bolen (1924), Wright (1929), Hile (1931), Tester (1932), and Hubbs and Hubbs (1931, 1933) The papers by Creaser and Hile give references to the contributions which introduced and have established the scale method for the determination of the age of fishes in general

The characteristics of the annulus or winter line on the scales of centrarchid fishes have been adequately indicated by the writers just

* Contribution from the Institute for Fisheries Research, University of Michigan.



MAP 46 Lower Peninsula of Michigan, showing (1) the mean annual temperatures in degrees Fahrenheit (solid line, after Seeley, 1922, Chart II), (2) the number of days in the growing season — the interval between killing frosts (dashed line, after Seeley, 1922, Chart XIV), and (3) the localities from which the material of long-eared sunfish was obtained The dividing lines between the northern and southern districts are fixed at 47° F and at 150 days in the growing season



MAP 47 Outline map of Michigan, showing (1) average number of days in the growing season (dotted line), and (2) the distribution of Michigan collections of green sunfish

cited, and need not be redescribed The figures of the scales on Plates CIV–CVIII show that the year marks on the scales of *Xenotis* and *Apomotis* are entirely like those of the other species of this family which have been studied

II INCREASED DWARFING TOWARD THE NORTH

In the central parts of the United States the long-eared sunfish (*Xenotis megalotis*) is a species of fair size Some data on its age and growth in northern Indiana have been published by Hile (1931 18, 23, 32, 42, 51) Northward it grades into a dwarfed subspecies, as Forbes and Richardson indicated, for Illinois, in 1909 (p 255)

> Northward this species grades into a smaller dwarfish variety, probably *Xenotis lythrochloris*, which has been taken only in the clear swift water of the Fox at Ottawa Lacon, and Algonquin, in the Du Page at Naperville, in the Vermilion at Pontiac and Fairbury, in a small creek in Du Page county, and in Indian creek, La Salle county These small forms have the ear-flaps red and the scales of the cheek smaller than typical *megalotis* Their size is alone sufficient to distinguish them, gravid females having been found only 1¾ inches long, and no specimen exceeding three inches

The proper name of this northern subspecies seems to be *Xenotis megalotis peltastes* (see Hubbs, 1926 72)

In Michigan we likewise find that the long-eared sunfish becomes progressively dwarfed toward the north The correlation is good between growth and certain climatic features, which change greatly through Michigan The two climatic gradients selected, from those mapped by Seeley (1922), as having a clear relation to the growth of this sunfish as determined by us, are (1) "the average number of days in the growing season (from last killing frost in spring to first killing frost in autumn)" and (2) "the mean temperature for the year" The distribution of our collections in respect to two divisions in each of these climatic gradients is shown in Map 46 An examination of the figure will make it clear that the groupings of the collections according to the two climatic divisions are identical

The data are summarized in Tables I and II and in Figure 57 It seems clear that *Xenotis megalotis peltastes* shows a dwarfing toward the north in Michigan, and that this dwarfing is correlated with a decrease in the mean length of the "growing season" (between killing frosts) and in the mean temperature of the year

As for the long-eared sunfish, we find for *Apomotis* in Michigan that a good correlation holds between growth rate and two climatic

TABLE I

Size Frequency Distribution of Long-eared Sunfish of Each Age Group in Michigan, Arranged according to Length of Growing Season

Standard length in millimeters by groups of five

Summer of life	Growing season in days	Mean temp	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85–89	90–94	95–99	100–104	105–109	110–114	Total
2d	110–150*	41–47°F	14	187	158	12																371
	110–150†	41–47°F		9	38	48	20	3	1													119
	150–180	47–49°F	1	2	2	6	22	20	2	1	1	2										59
3d	110–150	41–47°F			5	14	34	41	35	25	15	1	8	2								180
	150–180	47–49°F					8	32	34	17	15	18	11	4	2	1						142
4th	110–150	41–47°F					8	9	21	20	11	12	4	2	1							88
	150–180	47–49°F								3	2	7	7	7	6	2	1					35
5th	110–150	41–47°F							12	21	24	17	8	1								83
	150–180	47–49°F									1	5	7	3	5	3	2	1	1			28
6th	110–150	41–47°F						2	4	1	3	1		1	1					1		14
	150–180	47–49°F																			1	1
7th	110–150	41–47°F												1	1		1			1		4
	150–180	47–49°F																1			1	2
8th	110–150	41–47°F												1	1							2
	150–180	47–49°F																				
9th	110–150	41–47°F																				
	150–180	47–49°F																				
10th	110–150	41–47°F											1									1
	150–180	47–49°F																				
All ages	110–150	41–47°F	14	196	201	74	62	55	73	67	53	31	21	8	4		1			2		862
	150–180	47–49°F	1	2	2	6	30	52	36	21	19	32	25	14	13	6	3	2	1		2	267
Total			15	198	203	80	92	107	109	88	72	63	46	22	17	6	4	2	1	2	2	1 129

* The yearlings of one collection from Ross Lake Gladwin County collected June 26 In this collection only a few fish were older than yearlings.
† Miscellaneous localities and dates, as for all other rows

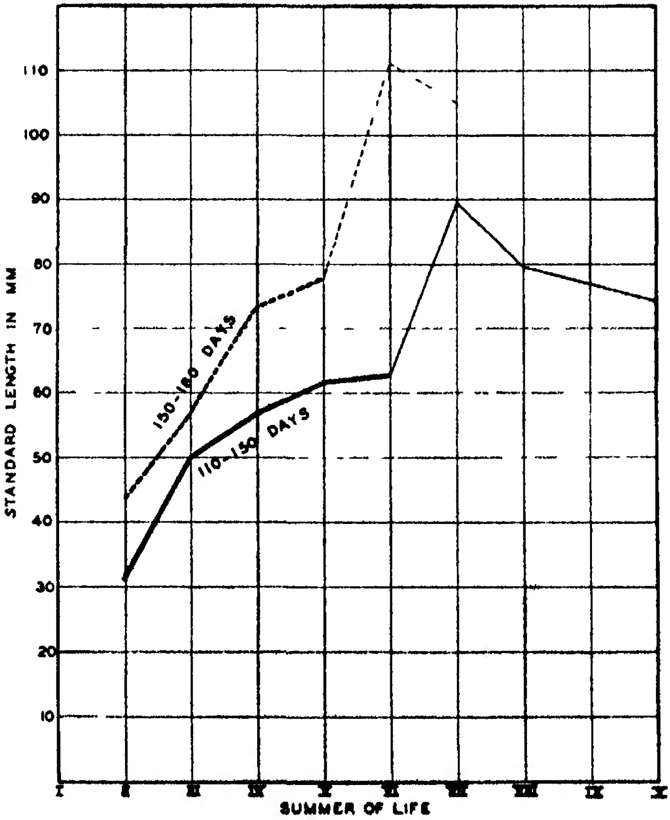


FIG 57 Correlation of growth rate of the long-eared sunfish in Michigan, with length of growing season Data from Table II

TABLE II

AVERAGE SIZE (STANDARD LENGTH IN MM) FOR LONG-EARED SUNFISH OF EACH AGE GROUP IN MICHIGAN, ARRANGED ACCORDING TO LENGTH OF GROWING SEASON AND MEAN ANNUAL TEMPERATURE

The inferior figure appended to each average represents the number of specimens on which the average is based

Growing season in days	Mean temp	Summer of life								
		2d	3d	4th	5th	6th	7th	8th	9th	10th
110–150	41–47° F	31 0$_{490}$	49 9$_{150}$	56 7$_{21}$	61 5$_{13}$	[illegible]2 5$_{14}$	89 3$_{4}$	79 5$_{2}$		74 0$_{1}$
150–180	47–49° F	43 5$_{40}$	56 6$_{148}$	73 2$_{25}$	77 7$_{28}$	111 0$_{1}$	105 0$_{2}$			

TABLE III

AVERAGE SIZE (STANDARD LENGTH IN MM) FOR GREEN SUNFISH OF EACH AGE GROUP IN MICHIGAN, ARRANGED ACCORDING TO OF GROWING SEASON

The inferior figure appended to each average represents the number of specimens on which the average is based

Growing season in days	Summer of life							
	1st	2d	3d	4th	5th	6th	7th	8th
110–150	19 8$_{80}$	44 0$_{129}$	59 8$_{57}$	80 8$_{22}$	91 7$_{11}$	114 [illegible]$_{3}$	114 4$_{5}$	158 0$_{1}$
150–180	11 0$_{6}$	40 8$_{44}$	65 6$_{32}$	89 2$_{45}$	118 3$_{7}$	127 5$_{12}$	146 5$_{6}$	145 0$_{1}$

TABLE IV

NUMBER OF SPECIMENS OF GREEN SUNFISH COLLECTED BEFORE JULY 11 AND AFTER JULY 10 FOR THE TWO CLIMATIC DISTRICTS OF EACH AGE GROUPING

Date of collection	Growing season in days	Summer of life							
		1st	2d	3d	4th	5th	6th	7th	8th
Before July 11	110–150	2	4	6		1			
	150–180	6	31	31	35	3	11	5	1
After July 10	110–150	78	125	51	22	10	3	5	1
	150–180		14	51	10	2	1	1	

gradients indicated by Seeley, "the average number of days in the growing season" and "the mean temperature for the year" The distribution of our collections of the green sunfish with respect to length of growing season is shown in Map 47 A change from this basis of classification to the mean temperature basis, with groupings of 39° to 47° F and of 47° to 50° F, would involve the transference of only nine specimens, in their second and third summers, representing three collections, and would in no way modify the conclusions A study of Table III and Figure 58 reveals a decreased growth rate in the northern part of the state The circumstance that the northern fish in the first and second summers were larger than the southern fish of the same age groups, though inconsistent with our general conclusion, is easily explained A separate tabulation of the number of specimens collected before July 11 and after July 10, for the two climatic districts in each age grouping (Table IV), shows that the majority of the northern fish (with a 110 150-day growing season) were collected after July 10, and that the majority of the southern fish (150–180-day season) were taken before July 11 Thus the fish from the northern area had lived through a longer portion of the last growing season than had the fish of the same age group from the southern area By the third and fourth summers the difference in size effected by climatic factors is more than sufficient to counterbalance the effect of this fortuitous difference in time of capture

III CORRELATION BETWEEN THE GROWTH OF THE FIRST AND OF THE SECOND YEAR

Some authors have indicated[1] a tendency toward "growth compensation" in several fishes, that is, an adjustment leading toward reduced variation in size with increasing age This would involve a negative correlation between early growth and later growth We find no evidence that this tendency holds for the growth of the long-eared sunfish in Michigan over the first two years of life (the period for which our data are adequate) A positive correlation exists between the growth of the first year and that of the second year for each sex in single collections (see Table V)

In computing the first year's growth from fish two years old (in

[1] Three such indications were referred to or given by Hubbs, *Ecology*, 2 275 1921

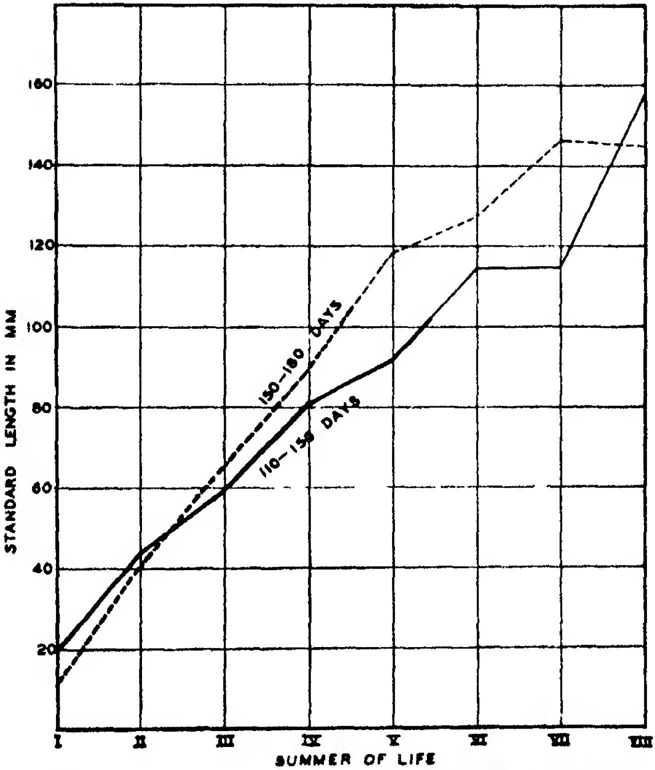


FIG 58 Correlation of growth rate of the green sunfish in Michigan, with length of growing season Data *from* Table III

TABLE V

CORRELATION BETWEEN GROWTH OF FIRST YEAR AND OF SECOND YEAR IN SUNFISHES IN MICHIGAN

Species	Growing season in days	Locality	Sex	No of speci mens	Coefficient of correlation (r)	Probable error of r (PE_r)	$\frac{r}{PE_r}$
Xenotis megalotis	110 130	Tomahawk Lake Montmorency Co	Male	12	+0 63	0 12	5
			Female	12	−0 42	0 16	3 −
Do	do	Bass Lake Kalkaska Co	Male	32	+0 54	0 08	6
			Female	18	+0 60	0 10	6
Do	150–180	Huron River Washtenaw Co	Male	22	+0 40	0 12	3 +
Do	do	Wilson Lake Hillsdale Co	Male	48	+0 76	0 04	19
			Female	20	+0 52	0 11	5
Eupomotis gibbosus	do	Crystal Lake Oceana Co	Male	90	+0 46	0 06	8
			Female	96	+0 47	0 05	9
Eupomotis × *Helioperca*	do	do	Male	67	+0 41	0 03	14
			Female	10	+0 54	0 12	4 5
Helioperca incisor	do	do	Male	92	+0 90	0 01	90
			Female	91	+0 79	0 03	26

third summer), the method of computation adopted by Hubbs and Hubbs (1933 619-623) was employed The scale measurements were made of the anterior embedded field along the median axis

The data used by Hubbs and Hubbs in the paper just cited show a similar positive correlation between the growth of the first year and that of the second year (up to the time of capture of the yearling fish on October 25) for two other species of sunfish and for the hybrids between them These data are included in Table V

The positive correlation between the growth of the first and of the second year in sunfishes means of course that those individuals of one sex at one locality which grow more than the average during the first year usually grow more than the average during the second year as well, whereas those which grow less during their first year usually grow poorly in their second year also This naturally leads to an increased dispersion in size with age — a phenomenon well shown in the size frequency graphs for separated age groups in sunfishes (Creaser, 1926, Fig 4, Hubbs and Hubbs, 1933, Figs 69–70)

The positive correlation between the growth of the first and of the second year at one locality may be due to any one of four reasons

(1) The individuals which attain a greater growth during their first year, owing to early hatching or any other factor, may possess such a competitive advantage over the slowly growing fish of the same age that they obtain more food during the second year In rearing sunfish in aquaria it was obvious that the larger fish became the masters, obtaining food first and worrying the smaller individuals in combat, at times to the point of death

(2) Some fish may select and inhabit through both years ecological niches particularly conducive to rapid growth, or the reverse

(3) The rate of growth in the first year may in some physiological way similarly affect the growth of the second year

(4) There may be genetic differences in growth potential between different individuals

IV DIFFERENTIAL GROWTH OF THE SEXES

It is a very general belief, as Van Cleave and Markus (1929 534) have indicated, that female fishes grow somewhat larger and presumably faster than the males There is, indeed, a very considerable body of evidence to indicate that the growth of the sexes is either very similar, or that the females grow faster than the males The general circumstance that very large specimens of many species are usually females is explainable in part as due to the greater growth of the females, but also in part as the consequence of the greater viability of the females

The long-eared sunfish forms a conspicuous exception to this apparently general rule that the female fish grow faster than the males of the same species Tables VI-VII and Figure 59 give adequate evidence that the males in this species grow faster than do the females A small difference is already apparent among yearling fish (that is, those in their second year), and becomes accentuated in the mature fish When the differential growth starts is uncertain It becomes apparent a year before first spawning It is rather doubtful, however, whether there is any significant difference in the average size of the sexes at the end of their first season's growth, that is, in their first winter (Table VIII) For all the sexed specimens of long-eared sunfish from Michigan in our collection (605 males and 491

TABLE VI

AVERAGE SIZE OF THE SEXES OF LONG-EARED SUNFISH OF EACH AGE GROUP, FOR EACH OF THE CLIMATIC DISTRICTS IN MICHIGAN

The inferior figure appended to each average represents the number of specimens on which the average is based

Growing season	Mean temp	Sex	Summer of life								
			2d	3d*	4th	5th	6th	7th	8th	9th	10th
110–150 days	41–47°F	Female	30 5$_{233}$	47 2$_{86}$	54 7$_{67}$	59 2$_{52}$	54 8$_{6}$	93 0$_{3}$	82 0$_{1}$		74 0$_{1}$
		Male	31 3$_{223}$	51 6$_{118}$	59 1$_{41}$	65 3$_{31}$	68 3$_{8}$	85 5$_{2}$	77 0$_{1}$		
150–180 days	47–49°F	Female	43 4$_{16}$	51 5$_{34}$	70 0$_{18}$	69 6$_{12}$		99 0$_{1}$			
		Male	46 0$_{38}$	58 2$_{101}$	75 2$_{19}$	84 7$_{12}$	110 0$_{1}$	110 0$_{1}$			

* Usual age at first maturity

TABLE VII

DEVIATION OF THE STANDARD LENGTH OF INDIVIDUAL MALE SPECIMENS OF LONG-EARED SUNFISH FROM THE MEAN LENGTH OF FEMALES OF THE SAME AGE GROUP IN THE SAME COLLECTION IN MICHIGAN

Only those age groups in any one collection which contain at least four females were used Measurements and computations are expressed to the nearest millimeter

Summer of life	Deviation in size of individual males from average size of females in millimeters											
	−13 to −11	−10 to −8	−7 to −5	−4 to −2	−1 to +1	+2 to +4	+5 to +7	+8 to +10	+11 to +13	+14 to +16	+17 to +19	+20 to +22
Second	1		10	30	90	73	27	2				
Third		1	8	11	15	16	15	14	14	5	6	4
Fourth					1	3	4	2	4	1	2	
Fifth				1	2	1	1	2	4	2		

females) the average size is 48 1 mm for males and 43 3 mm for females This is presumably not due to a greater longevity of the males, because the males seem to be less viable than the females (see section below on sex ratios)

In the green sunfish also the males grow faster than the females (Table IX and Fig 60) The difference in the size of the sexes in their second summer, as determined by averaging the lengths of all specimens studied, is slight and seemingly not significant A com-

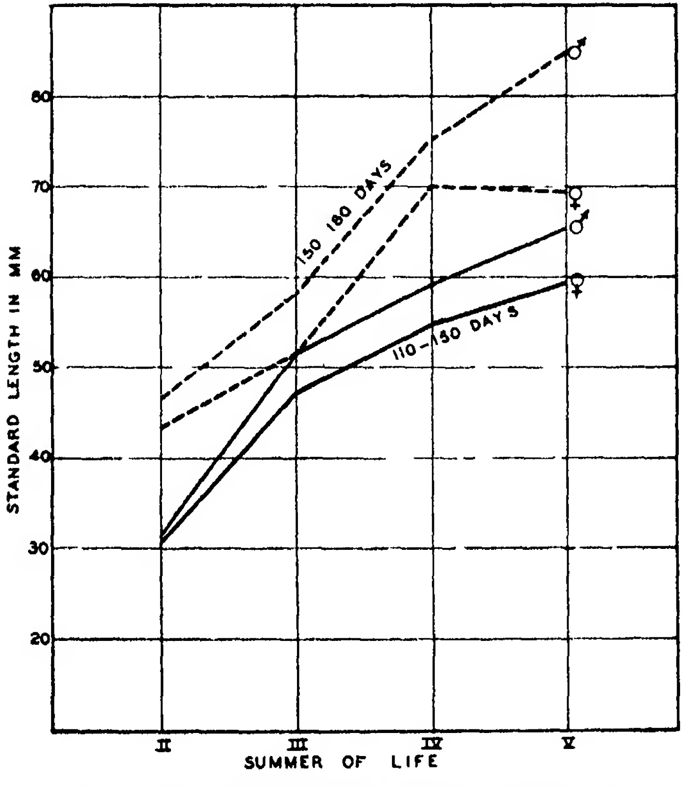


FIG 59 Growth curves of the two sexes of long-eared sunfish in the two growing-season districts of Michigan Data from Table VI

parison of the sizes of specimens of each sex within single collections (Table X) shows that the males apparently average somewhat larger than the females even before maturity is attained The sexual dimorphism in size seems to increase during the third and fourth summers, and probably also throughout the still older year groups, though these are represented by too few specimens to yield certain conclusions

TABLE VIII

COMPARATIVE SIZE OF SEXES OF LONG-EARED SUNFISH IN THREE COLLECTIONS FROM MICHIGAN, AT THE END OF THEIR FIRST SEASON'S GROWTH, AS COMPUTED FROM FISH IN THEIR THIRD SUMMER

Growing season	Locality	Sex	No of specimens	Average size
110–130 days	Tomahawk Lake, Montmorency Co	Female	12	22.6
		Male	12	21.7
110–130 days	Bass Lake, Kalkaska Co	Female	18	23.7
		Male	32	24.3
150–180 days	Wilson Lake, Hillsdale Co	Female	20	20.3
		Male	48	20.6

TABLE IX

AVERAGE SIZES OF THE SEXES OF GREEN SUNFISH IN EACH AGE GROUP, ARRANGED ACCORDING TO THE LENGTH OF THE GROWING SEASON

The inferior figure appended to each average represents the number of specimens on which the average is based

Growing season	Sex	Summer of life						
		2d	3d	4th	5th	6th	7th	8th
110–150 days	Female	44.9_{60}	59.2_{33}	75.6_{8}	83.0_{3}	96.0_{1}		
	Male	45.4_{34}	62.0_{32}	83.8_{14}	93.7_{6}	123.5_{3}	114.4_{6}	158.0_{1}
150–180 days	Female	41.7_{36}	59.8_{36}	81.1_{19}	110.3_{3}	126.3_{4}	122.0_{1}	
	Male	40.8_{14}	70.0_{47}	95.2_{26}	124.3_{4}	128.1_{6}	151.4_{4}	145.0_{1}

It is probable that the males of at least most species in the family Centrarchidae grow faster than the females This was suggested by Creaser's data (1926, Fig 3) for *Eupomotis gibbosus*, and was definitely indicated by Tester (1932 215) to hold for *Micropterus dolomieu* Hubbs and Hubbs (1933 622) showed that the males of *Eupomotis gibbosus*, of *Helioperca incisor*, and of hybrids between them grow at about the same rate as the females during their first year of life, but at a faster rate during their second year Dr Ralph Hile informs us that the males of *Ambloplites rupestris* grow faster than the females

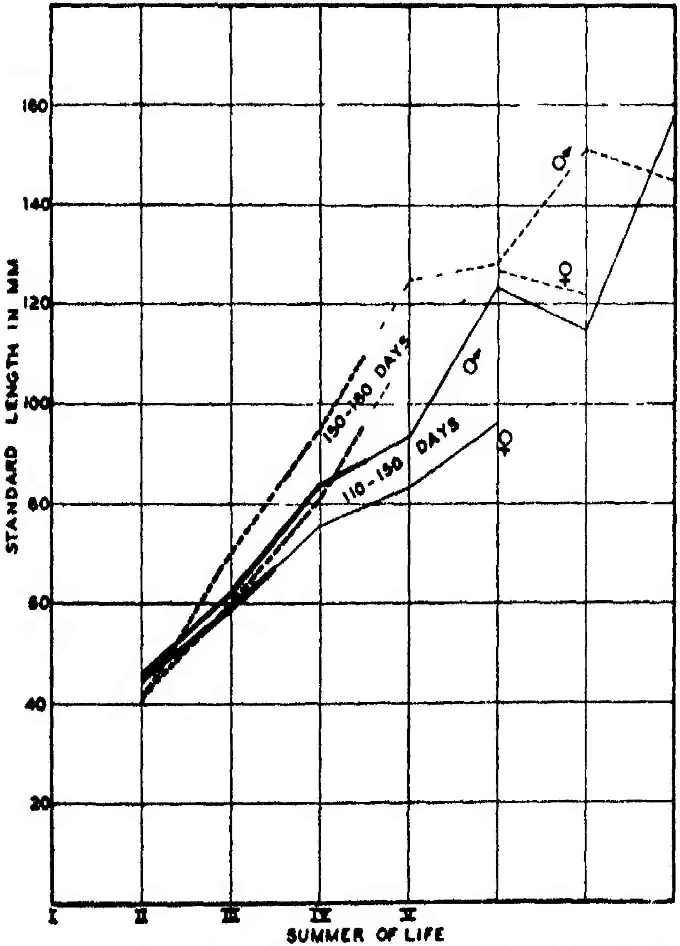


FIG 60 Growth curves of the two sexes of green sunfish in the two growing-season districts of Michigan Data from Table IX

TABLE X

DEVIATION OF THE STANDARD LENGTH OF INDIVIDUAL MALE SPECIMENS OF GREEN SUNFISH FROM THE MEAN LENGTH OF FEMALE SPECIMENS OF THE SAME AGE GROUP AND COLLECTION IN MICHIGAN

Only those age groups in any one collection which contain at least four females were used. Measurements and computations are expressed to the nearest millimeter

Summer of life	Deviation in millimeters																
	−10 to −8	−7 to −5	−4 to −2	−1 to +1	2 to 4	5 to 7	8 to 10	11 to 13	14 to 16	17 to 19	20 to 22	23 to 25	26 to 28	29 to 31	32 to 34	35 to 37	38 to 40
Second	4	4	8	5	3	11	4	2	2	1		1					
Third	1	1	4	2	4	7	5	3	4	2	2	2					1
Fourth			1	1	2		2	2	1	2	1	2			1		

The significance of this apparently altered differential growth rate of the sexes is of course a matter of speculation. Our supposition is that the increased growth of the males has been of selectional significance, enabling them the better to ward off enemies from the nests which they guard so pugnaciously.

This hypothesis will of course be very difficult to test. It receives confirmation, however, from the differential growth rate of the sexes in Cyprinidae. In that family most species show no specific nest-building or nest-guarding habits, and in these forms the females reach as large a size as the males or become larger, and probably grow as fast or faster. But there are some notable exceptions, in which the male becomes much larger than the female. These are the very species which build or guard some sort of nest, or perform both functions. This correlation of differential growth rate with breeding habits can hardly be a coincidence, since it involves a considerable number of unrelated genera. The greater growth rate of the male has been indicated in published papers for two cyprinids, for *Hyborhynchus notatus* by Van Cleave and Markus (1929), and for *Semotilus atromaculatus* by Greeley (1930). Hubbs and Creaser observed this phenomenon in 1921, not only for the two species just mentioned, but also for *Nocomis biguttatus* and *Notropis cornutus frontalis*. Males of other American cyprinids which guard the eggs grow larger than the females, notably the other subspecies of *Notropis cornutus*, and *Nocomis micropogon*, *Leucosomus corporalis*, *Exoglossum*

maxillingua, *Pimephales promelas*, and *Campostoma anomalum* Professor Yuanting T Chu calls our attention to the fact that the males of an Asiatic cyprinid, *Pseudorasbora parva*, likewise guard the eggs and grow larger than the females

V SEX RATIO

Among the second-summer or yearling specimens of the long-eared sunfish, almost all immature, the two sexes are represented in approximately equal numbers About seven tenths of the fish a year older, in their first usual year of maturity, are males This aberrant sex ratio is certainly not representative of the actual natural population, but obviously results from the extreme ease of collecting the gregariously breeding males on their nests in shallow water But by the next year (fourth summer) the sexes in the collections are again approximately equal, suggesting an actual preponderance of the more retiring females For subsequent years the females in the collections somewhat outnumber the males, and are presumably decidedly more numerous in nature Of the three oldest fish two are females in their eighth and tenth summers, and one is a male in its eighth summer The data are given in Table XI

Data on the sex ratio in *Apomotis cyanellus*, given in Table XII, show an increasing percentage of males among the older fish, thus contrasting with the condition found in *Xenotis* Since the males of *Apomotis* are not so gregarious in their breeding, collections having an abnormally large number of that sex do not occur As an apparent consequence the sexes are more evenly represented in the collections of green sunfish The increasing ratio of males in *Apomotis* with age suggests that the males are more viable than the females This is contrary to the general rule as well as to the situation found for *Xenotis*, and needs confirmation

VI AGE AND SIZE AT MATURITY, AND SUBSEQUENT LIFE HISTORY

Xenotis megalotis in Michigan appears to mature at a definite age rather than at a definite size In both the southern and northern parts of the state the great majority of individuals mature first at the age of two years, that is, in their third summer This is true despite the circumstance that the immature yearlings in the south are often as large, usually 40 to 50 mm in standard length, as the average mature two-year-old fish in the north In their first summer of

TABLE XI

Sex Ratios for Long-eared Sunfish as Determined from the Michigan Specimens Studied

Summer of life	Usual maturity	No of males	No of females	Percentage of males
Second	Immature (yearlings)	265	252	51
Third	First year of maturity	221	100	69
Fourth	Second year of maturity	60	63	49
Fifth to tenth	Subsequent years (mature)	59	76	44

TABLE XII

Sex Ratios for Green Sunfish as Determined from the Michigan Specimens Studied

Summer of life	Maturity	No of males	No of females	Percentage of males
Second	Almost all immature	72	86	46
Third	About 75% mature	69	68	50
Fourth	All mature	40	27	60
Fifth to eighth	All mature	36	11	77

maturity the long-eared sunfish in southern Michigan are usually 45 to 75 mm in standard length (2 0 to 3 5 inches in total length), while those in northern Michigan are usually 35 to 65 mm in standard length (only 1 5 to 3 0 inches long over all) during this first season of maturity (Tables I and XIV)

There is little variation in the age at maturity of long-eared sunfish in Michigan Occasional large yearlings at scattered localities are mature, or maturing so as to spawn in their second summer Similarly a few two-year-old (third-summer) fish are immature, and, in agreement with this, a few fish show no trace of a spawning mark on their scales inside the third winter line

A considerable percentage of the long-eared sunfish in Michigan which reach maturity live through three years of maturity (Tables I and XIV) About as many four-year-old as three-year-old fish appear in the collections studied Relatively few, however, live to be older, for both sections of the state there is a sharp drop in numbers between the fifth and the sixth summer of life Of the 1,129 fish

studied only 6 are in the seventh summer, 2 in their eighth, and 1 in its tenth year (approximately nine years old) All three of the eighth- and tenth-summer fish are from the northern growing district (110–150 days) Of the 24 fish in their sixth to tenth year, 21 (nearly 90 per cent) are from the northern district, although only 64 per cent of the total number of fish studied, yearlings excepted, are from that district

All the green sunfish in Michigan appear to be mature in their fourth and subsequent summers Roughly about three fourths of the third-summer fish and a very few of the second-summer fish are mature In single collections the early spawners within a given year group are the larger individuals of that year group, yet no significant differences in age of maturity are correlated with the differential growth rates of fish from the northern and the southern parts of the state, or with sex The over-all size at first maturity for both sexes averages slightly over three inches in the southern part of the state, and slightly under three inches in the northern district Greater longevity in the region of slower growth is indicated by the data, in our collections from the southern and the northern areas the relative numbers of individuals in each summer of life from the first to the eighth, are 80 6, 129 45, 57 83, 22 45, 11 7, 3 13, 5 6, 1 1 The ages and sizes of the green sunfish at maturity are indicated in Tables XII and XV

VII THE SPAWNING SEASON

Observations of nesting fish, supplemented by the examination of the gonads of preserved specimens, show that the spawning season of the long-eared sunfish in Michigan centers in July, but extends from the latter part of June into early August Like other distinctly summer spawners, it does not mature the gonads during the fall preceding spawning, as do most of our early spring spawning fishes

Our observations of the green sunfish indicate a prolonged spawning season for this species in Michigan This is especially obvious from our data on the size distribution of the young of the year, given in Table XIII The first two entries in this table definitely indicate June spawning, the sizes of the young of subsequent collections make it clear that spawning extends through July and probably into August, to judge from the growth attained at the time of capture Gravid females occur in collections made as early as June 25 and as

TABLE XIII

SIZE OF GREEN SUNFISH IN THEIR FIRST SUMMER OF LIFE IN SINGLE COLLECTIONS FROM MICHIGAN

Growing season in days	Lake	County	Date	Mean length, in mm	No of specimens
150 180	Third Sister Lake	Washtenaw	July 1	11 0	6
110–150	Whipple Creek	Newaygo	July 9	31 0	2
Do	Railroad Lake	Lake	July 18	17 0	1
Do	Little Log Lake	Kalkaska	August 9	18 0	1
Do	Highbank Lake	Newaygo	August 24	18 1	34
Do	Kichners Lake	Menominee	August 30	21 8	29
Do	Cranberry Lake	Kalkaska	Sept 11	20 2	5
Do	Sand Lake	Newaygo	Sept 17	16 0	1
Do	Onatoga Lake	Otsego	Sept 27	23 0	1
Do	Horseshoe Lake	Otsego and Crawford	Sept 29	16 7	6

late as July 27 Males in southern Michigan retain running milt as late as September 28 Forbes and Richardson (1909 250) indicated spawning of the green sunfish in Illinois as late as August 14

VIII THE SPAWNING MARK ON THE SCALES

Several who have worked on the life history of centrarchid fishes have noted "double annuli" which we have thought might reflect checks in growth due to both winter and breeding Now we feel justified in stating, for the long-eared and the green sunfishes at least, that spawning is usually registered on the scale by a definite mark (Pls CIV–CVIII) The spawning mark is closely associated with and lies within a winter annulus, usually within each annulus from the third one out to the last one shown on the scale This spawning mark indicates an abrupt though temporary slackening or cessation of growth during the breeding season

The spawning mark is most clearly evident across the anterior or concealed field of the scale and in the anterior portion of the lateral fields Here it is often more conspicuous than the true winter line It often appears as a definite clear break across the anterior field, caused largely by the straightening out of the ridges (circuli) between the radii Between a spawning mark and the preceding annulus the ridges are usually strongly curved inward between each two radii,

whereas from the spawning mark outward to the following annulus the ridges are usually straight. This change in the curvature of the ridges tends to leave clear lenticular gaps along the line of the spawning mark.

The ridges representing the spring growth out to the spawning check are widely spaced; those representing the fall growth outside the spawning mark are often (though by no means always) more densely crowded, so as to form a dark band across the anterior field of the scale. This dark band of crowded ridges when developed is usually continued around and just back of the anterolateral angles. Rarely the breeding mark may be traced into or even across the posterior or exposed field of the scale, separate from the winter annulus, though usually the two marks merge together in advance of the posterolateral angle. This would seem to indicate that the scale grows chiefly in the anterior direction after the spawning time, thus embedding the scale more deeply into the flesh. Dorsoventral growth of the scale seems to be very slight after spawning, except toward the anterolateral angle, along which the growth is about as great as on the anterior field.

The more complete spawning marks have probably been mistaken occasionally by previous investigators for winter annuli. A thorough understanding of the features of the two marks should make such errors in age determination very rare.

Although as stated above the spawning season of the long-eared sunfish in Michigan centers in July, extending from late June to early August, the spawning mark is usually much nearer the following winter annulus than the preceding one. This suggests that a very rapid spring growth and a more sluggish late summer and fall growth is the rule. The wide spacing of the circuli laid down prior to spawning and the crowding of the post-spawning circuli are in harmony with this view that the growth is slackened in the later part of the season.

The formation of the spawning mark is clearly coincident with breeding. Scales from either species taken in the late spring prior to spawning show the widely spaced ridges characteristic of spring growth, without a trace of a spawning mark near the margin. Scales from male long-eared sunfish taken on their redds in the Huron River, Michigan, on June 28, show little indication of a spawning mark, whereas almost all those taken on their nests in the same river on

July 7 and 9 show a spawning mark forming or completely formed, at or very near the margin of the scale Autumn-taken fish have scales showing the spawning mark well inside the margin

IX RELATION OF SIZE AND GROWTH TO LEGAL LIMIT

The laws of Michigan, as they now stand (March, 1934), list the long-eared sunfish (*Xenotis megalotis peltastes*) and the green sunfish (*Apomotis cyanellus*) as game fishes, and stipulate the legal size limit of these species as six inches

Not one long-eared sunfish among the 1,129 specimens available for the present research is so large (see Table XIV) It is doubtful whether one long-eared sunfish per thousand mature fish in Michigan is of legal size Less than 0 5 per cent of our examples are more than 5 inches long Only 1 in 18 or 19 is more than 3½ inches long This species is clearly not in need of any protection in the way of a legal size limit Placing a legal size limit of 6 inches, or of 5 or even of 4 inches, on this species gives it complete or almost complete protection

Only 4 per cent of the green sunfish specimens studied are of legal size (Table XV) Whether this percentage is representative of the natural fauna or not is debatable, since most collecting is done in shallow water with small seines and is somewhat selective of the smaller fish However, of the twenty fish of legal size, eleven were collected by Professor T L Hankinson in Oakland County, mostly from Walnut Lake Since his collections included only five specimens under the legal size, he obviously selected for preservation chiefly the larger fish This compensates more or less for the selectiveness of seining methods for the smaller fish This selectivity is probably not severe anyway, since the green sunfish is a shoal-loving species All the legal-sized fish were taken from lakes, 85 per cent from the southern part of the state (150–180-day growing season), and hence only 15 per cent from the northern district (110–150-day growing season) Of the fish studied only one in one hundred from the northern zone is of legal size If the selected Walnut Lake collections be excluded, only one fish in thirty-two from the southern zone is of legal size

Protecting these dwarfed sunfishes apparently has no beneficial effects, and may be decidedly harmful to fishing for pan fish in certain inland lakes They must to a considerable degree compete with the pumpkinseed and bluegill sunfishes for food and for spawning

TABLE XIV

DISTRIBUTION OF SPECIMENS OF LONG-EARED SUNFISH ACCORDING TO TOTAL LENGTH IN INCHES AND TO MATURITY

Summer of life	Growing season in days	Total length, including caudal fin, in inches																
		0.9–1.1	1.2–1.4	1.5–1.7	1.8–2.0	2.1–2.3	2.4–2.6	2.7–2.9	3.0–3.2	3.3–3.5	3.6–3.8	3.9–4.1	4.2–4.4	4.5–4.7	4.8–5.0	5.1–5.3	5.4–5.6	Total
2d*	110–150	8	200	213	56	10	2	1										490
	150–180		4	2	14	26	9	1	2	1								59
3d	110–150			10	23	42	52	32	11	8	1	1						180
	150–180					28	48	19	21	19	3	4						142
4th	110–150				2	11	19	27	12	13	4							88
	150–180							3	4	11	5	9	3					35
5th	110–150						8	28	24	20	2	1						83
	150–180								1	12	3	5	5	1	1			28
6th	110–150					2	4	1	3	1	1		1				1	14
	150–180															1		1
7th	110–150										1	1	1			1		4
	150–180														1	1		2
8th	110–150										1	1						2
	150–180																	
9th	110–150																	
	150–180																	
10th	110–150										1							1
	150–180																	
All ages	110–150	8	200	223	81	65	85	89	50	42	11	4	2			1	1	862
	150–180		4	2	14	54	57	23	28	43	11	18	8	1	2	2		267
Total		8	204	225	95	119	142	112	78	85	22	22	10	1	2	3	1	1 129

* Almost all immature

TABLE XV

DISTRIBUTION OF SPECIMENS OF GREEN SUNFISH ACCORDING TO TOTAL LENGTH IN INCHES AND TO MATURITY

Summer of life	Growing season in days	Total length including caudal fin in inches																									
		0.3 to 0.5	0.6 to 0.8	0.9 to 1.1	1.2 to 1.4	1.5 to 1.7	1.8 to 2.0	2.1 to 2.3	2.4 to 2.6	2.7 to 2.9	3.0 to 3.2	3.3 to 3.5	3.6 to 3.8	3.9 to 4.1	4.2 to 4.4	4.5 to 4.7	4.8 to 5.0	5.1 to 5.3	5.4 to 5.6	5.7 to 5.9	6.0 to 6.2	6.3 to 6.5	6.6 to 6.8	6.9 to 7.1	7.2 to 7.4	7.5 to 7.7	Total
First	110–150		34	28	17	1																					80
	150–180	4	2																								6
Second	110–150				3	17	38	36	21	5	6	3															129
	150–180			1	2	12	14	5	4	6	1																45
Third	110–150							5	13	17	10	6	2	1	1	2											57
	150–180							2	13	12	21	13	12	5	3		1		1								83
Fourth	110–150									1	2	3	5	3	3	3	1	1									22
	150–180											2	10	6	8	7	7	3	2								45
Fifth	110–150											1		2	2	3	1	1	1								11
	150–180													1				2	1		2	1					7
Sixth	110–150															1		1					1				3
	150–180																1		3	1	3	3		1	1		13
Seventh	110–150																	2	2		1						5
	150–180																			1				3	2		6
Eighth	110–150																									1	1
	150–180																						1				1
All ages	110–150		34	28	20	18	38	41	34	23	18	13	7	6	6	9	2	5	3		1		1			1	308
	150–180	4	2	1	2	12	14	7	17	18	22	15	22	12	11	7	9	5	7	2	5	4	1	4	3		206
Total		4	36	29	22	30	52	48	51	41	40	28	29	18	17	16	11	10	10	2	6	4	2	4	3	1	514
Maturity		Almost always immature Less than three inches long									Mostly mature but below legal size Three to six inches long										Always mature and of legal size Six inches or longer						
% total population		61%									35%										4%						

grounds The competition for food between the adults of the long-eared sunfish and the half-grown of the larger species must be rather severe, especially when the long-eared sunfish becomes abundant The voracious habits of the green sunfish make it an even worse competitor of the bluegill and pumpkinseed Its large mouth even enables it, when adult, to eat the same kind of food as the larger young or even the half-grown of the larger game fishes It even tends to be a predator When it becomes abundant, it must have an effect on the population of the larger species

Both the long-eared and green sunfishes do in fact swarm and dominate in certain inland lakes of the state In all probability the complete or almost complete protection accorded these species by the law has been conducive to their increase The larger and better sunfish species have suffered a drain and depletion, while the survival of the dwarf species has been favored

Another potentially harmful effect of multiplying the numbers of these dwarfed species is the increase in number of interspecific hybrids Whereas these hybrids are not dwarfed, they are infertile, though they vigorously monopolize the sunfish spawning grounds throughout the warm season (Hubbs and Hubbs, 1931, 1933)

It is true that the long-eared sunfish is not generally distinguished by Michigan anglers from the larger species, but the green sunfish is confused with the warmouth bass (*Chaenobryttus gulosus*) under the name of "mud bass" It is claimed by some that a special size limit on the two species would lead to confusion in the enforcement of the law Our recommendation, however, is that both be removed from the list of game fish entirely, and that the legal limit for "sunfish" be specified as applying to the pumpkinseed and the bluegill This would allow cottagers (and their children) to remove the excess of the long-eared and green sunfishes when overabundant, after they have learned the identity of the dwarfed species

In more southern states both the long-eared and the green sunfish attain a more respectable size, and in places rank as pan fishes of some importance In the Ozarks the green sunfish readily takes the fly, and has a good reputation as a game fish, though in some isolated ponds and in creeks throughout its range it swarms and becomes dwarfed The recommendations for a change in the legal status of the long-eared and green sunfishes apply to Michigan only For the lakes in northern Indiana Hile (1931 42) concluded that "It is

doubtful whether legal size [five inches] is reached [by the long-eared sunfish] before the fourth growing season, and some individuals in the III, IV, and V groups scarcely pass the scrutiny of the law" In Ohio no size limit is stipulated for either the long-eared or the green sunfish (there is a bag limit of twenty per day for all sunfishes combined), even though both species tend to grow larger in that state than in Michigan Milton B Trautman informs us that in certain of the smaller Ohio ponds protected from fishing the green sunfish excludes the other species, and becomes so numerous as to be dwarfed

X SUMMARY

1 This study was based on the age determination of 1,129 long-eared sunfish (*Xenotis megalotis peltastes*) and of 514 green sunfish (*Apomotis cyanellus*) from Michigan, using the scale methods now becoming standard

2 These species become more dwarfed toward the north in Michigan, in good correlation with a shortened growing season and lower mean annual temperature

3 There is no evidence for "growth compensation" In three genera of Centrarchidae, *Xenotis, Helioperca*, and *Eupomotis*, a positive correlation exists between the growth of the first and of the second year

4 In *Xenotis* and *Apomotis*, as in other centrarchids, the male grows faster than the female This unusual relation may be an adaptation, since larger size would obviously be of advantage to these nest-guarding fishes In the Cyprinidae likewise the males grow larger than the females in those species in which the male guards the eggs

5 In *Xenotis* the females apparently live longer than the males, on the average Our data for the green sunfish indicate, anomalously, that the males are more viable than the females

6 Attainment of maturity in both species is related to age (usually just two years) rather than to size Greatest longevity is probably attained in the region of greatest dwarfing Maximum indicated age for the two species in Michigan is nine years for the long-eared sunfish and seven years for the green sunfish

7 Both species are summer spawners, nesting from the latter part of June at least into August

8 A definite spawning mark is usually produced on the scale of

both species, indicating a slackening or cessation of growth during spawning Spring growth (prior to spawning) appears to be more vigorous than late summer and fall growth

9 Since the long-eared sunfish very seldom if ever attains its designated legal length of six inches in Michigan, and since relatively few green sunfish exceed that length, these species are obviously not in need of such legal protection Maintaining them as game fishes favors their increase They tend to become overly abundant, and probably compete with the better species for food It is recommended that they be omitted from the list of designated game fishes and that they be exempted from any size or bag limit

University of Michigan

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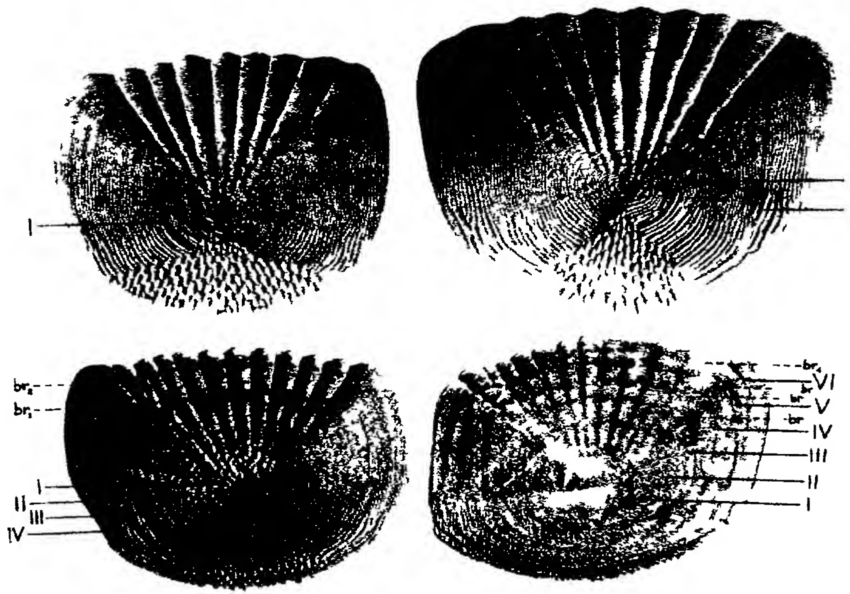
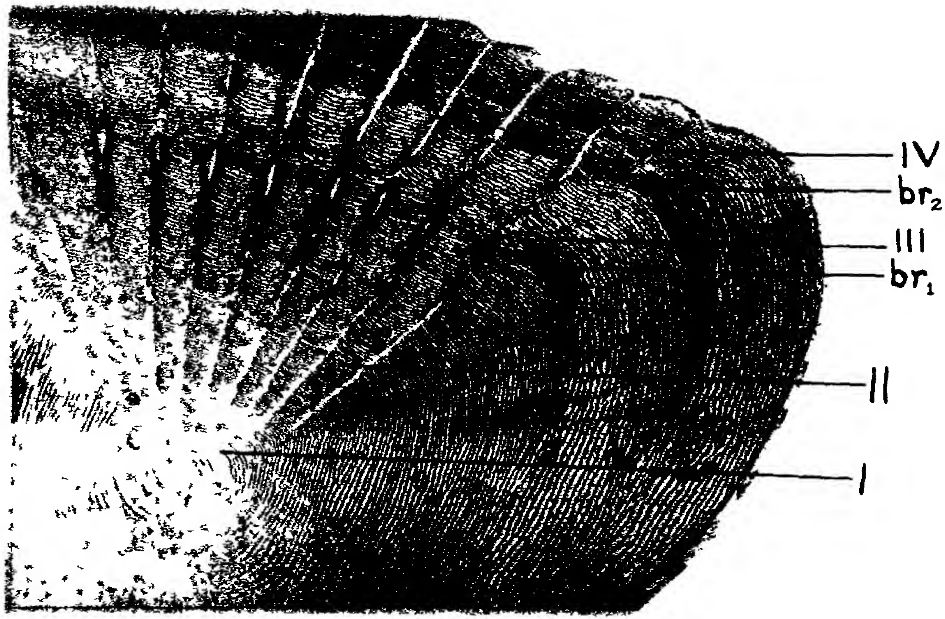


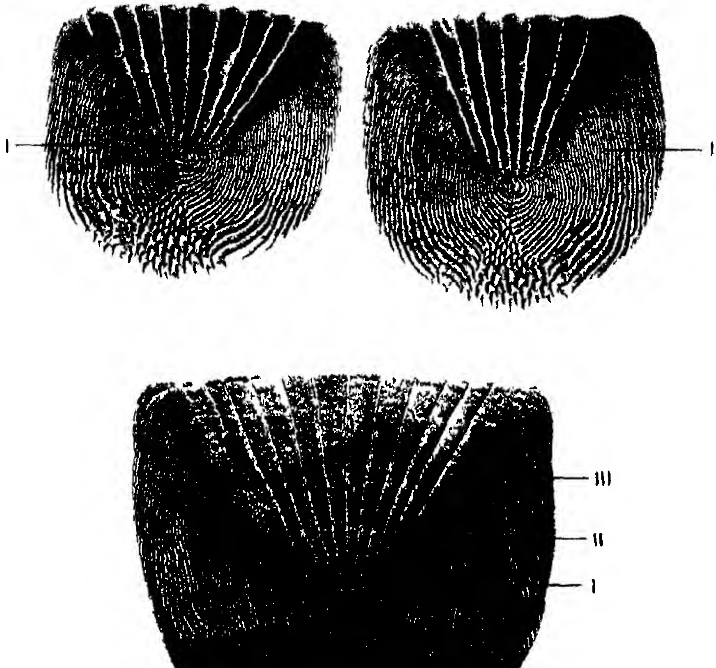
Scales of long-eared sunfish from Michigan showing respectively 1, 2, 4 and 6 winter mark annuli. The older scales show in addition 2 and 4 spawning checks br. The older scales are magnified less than the younger two

PLATI



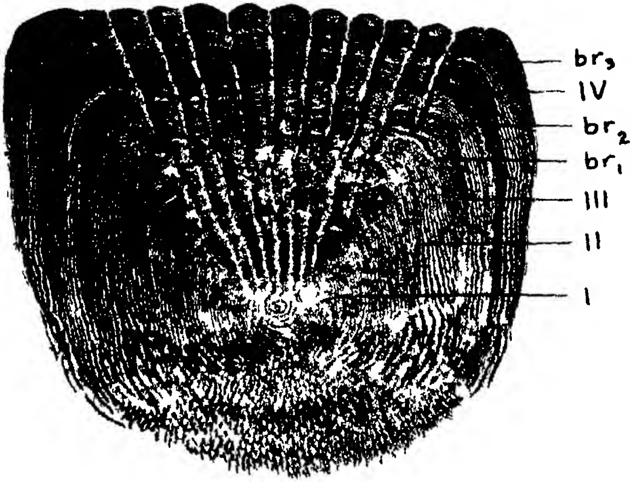
le of a four year-old long-eared sunfish from Michigan much magnified to h s the de ails of th spawn ing checks (br and br The Roman numerals as in the preceding plate refer to he v ter nnuli

PLATE CVI

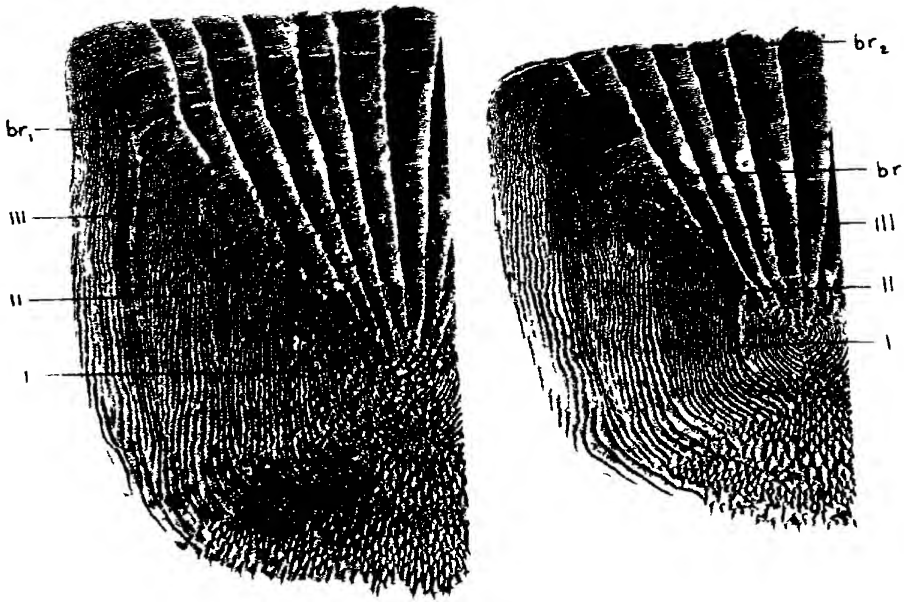


Scales of green sunfish. The two scales showing one winter mark were taken from the same fish, an immature female, standard length of 49 mm., collected in Third Sister Lake, Washtenaw County, on July 1, 1922. The scale showing three winter marks was taken from an adult male, standard length of 92 mm., collected in Long Lake, Hillsdale County, on July 9, 1931.

PLATE CVII



Scale of an adult male green sunfish, standard length of 90 mm., collected in Bass Lake, Newaygo County, on August 30, 1926. Four winter marks (I–IV) and three spawning checks (*br_1–br_3*) are indicated.



Sections of green sunfish scales enlarged to show structural details of the spawning check and winter mark. Both fish from which these scales were taken were gravid females ready to spawn, collected in Long Lake, Hillsdale County, on July 9, 1931. Each scale indicates three winter marks. On one scale the second spawning check had just been formed at the margin, whereas on the other scale the second spawning check had not as yet been formed.

STUDIES ON THE LIFE HISTORY OF A FROG BLADDER FLUKE, *GORGODERA AMPLICAVA* LOOSS, 1899

WENDELL H KRULL

CONTENTS

INTRODUCTION

IN THE life history of *Gorgodera amplicava* Looss as determined experimentally the frogs *Rana clamitans* Latr and *R catesbeiana* Shaw have been used as definitive hosts, and a clam, *Musculium partumeium* Say, and a snail, *Helisoma antrosa* Conrad, as the first and second intermediate hosts, respectively The abstract by Krull (1933*b*) is, apparently, the first paper to appear on the life history of frog bladder flukes in the United States, in this note *Musculium partumeium*, *Helisoma antrosa*, and *Rana clamitans* were reported as first and second intermediate hosts and definitive host, respectively, of a gorgoderid fluke now determined as *Gorgodera amplicava* Looss In the present paper the larval stages of this fluke are described in full and the experiments establishing the life history are given, in addition, a new local definitive host, *Rana catesbeiana*, is reported The two definitive hosts are commonly found to be naturally infected with *G amplicava*, which is the only frog bladder fluke that has been taken in the local Beltsville area in two years of collecting Bensley

(1897), who described *G amplicava* under the name of *Distomum cygnoides,* reported it from the frogs *Rana clamitans, R virescens,* and *R catesbeiana,* and subsequently Stafford (1902), Cort (1912), Guberlet (1920, identified as *G circava,* sp nov) and Harwood (1932) recorded the fluke from *R catesbeiana*

Sinitsin (1905) described the larval stages of several frog bladder flukes and discovered that the large active tails of the cercariae served as lures for certain insect larvae which became infected by eating the cercariae He observed also that there was a decided difference in the relative activity of the different cercariae Furthermore, by inconclusive experiments, he found that larval *Epitheca* could be infected with the cercaria of *Gorgodera loossi* and that the resulting metacercariae, when fed to a frog, developed into *Gorgodera loossi* Sinitsin, and that larval *Agrion* could be infected with the cercaria of *Gorgodera varsoviensis* and that the resulting metacercariae, when fed to a frog, developed into *Gorgodera varsoviensis* Sinitsin

The writer has had occasion to observe, in the Douglas Lake region and at Ann Arbor, Michigan, similar frog bladder fluke cercariae shed by clams of the family Sphaeriidae Encysted frog bladder fluke metacercariae were found in naturally infected nymphs and imagoes of damsel flies, *Lestes sp*, and the nymphs of these insects also could be infected under laboratory conditions by feeding them cercariae which, when they penetrated the digestive system, produced a definite and decided response in the nymphs similar to those described by Sinitsin

The life history of *Gorgodera amplicava,* subsequently discussed, is peculiar in two respects (1) The tail of the cercaria of *G amplicava* is immobile and exceedingly long in comparison with that of other forms, and (2) a snail instead of an insect, as in the case of other frog bladder flukes for which comparable parts of the life history are known, serves as the second intermediate host The idea that a snail might be a second intermediate host of a frog bladder fluke is not new, for Thiry (1859) concluded, on the basis of the excretory system and the discarded stylet, that encysted larvae found by him in small lymnaeid snails were those of *Cercaria macrocera.* Sinitsin, in his comment on Thiry's discovery, stated that it was only possible to say that Thiry had observed a young distome, and that it was absurd to think that the encysted larva was a frog bladder fluke, since it was inconceivable that the host, the small *Lymnaea,*

would be used as food by frogs, because normally they did not feed on mollusks

It has been the experience of the writer that snails, both terrestrial and aquatic, are rather commonly encountered in the digestive systems of frogs collected under natural conditions, and he has found a fully grown *Polygyra albolabrus* in the stomach of a moderate-sized frog That mollusks are eaten by frogs is easily demonstrated by putting mollusks and frogs together for a couple of days in an aquarium containing about two inches of water, during this time most of the snails are usually eaten

DESCRIPTION OF LARVAL STAGES

Sporocyst

Daughter sporocyst large, 1 1 to 3 5 mm (average 2 6) long by 230 to 360 μ (average 330) wide, tubular, with one end constricted for a short distance Wall of sporocyst rather thick and rough, with large semicircular flame cells (Pl CIX, Fig 1) A single sporocyst may have as many as sixteen fully grown cercariae

The sporocysts occupy the proximal ends of the gills of the clam and are more or less free except for the constricted ends, which are mobile and buried in the gill tissue and which, apparently, serve as holdfast organs In some of the sporocysts this constricted end is open, and cercaria bodies without the tails have been observed to crawl out of this end when the sporocysts were mounted on a slide, indicating that this opening is possibly a birth pore through which the cercariae are discharged

The peculiar flame cells of the sporocyst are very large, some being 53 μ wide The limiting membrane of the cell proper could not be determined, but the nucleus and the cytoplasmic parts, as indicated in Figure 1, were always observed The semilunar portion of the cell, which contains the vibratile, platelike structures, narrows between the two ends and opposite the nucleus to form a duct, as shown in Figure 1 These flame cells have been described as present in *Distomum cygnoides* (= *Gorgodera cygnoides*) by Looss (1894) and in the sporocyst of *Phyllodistomum folium* by Sinitsin (1905)

Cercaria

Cystocercus cercaria (Fig 2), 4 4 to 7 5 mm (average 6 0) long, differentiated into an anterior chamber 350 to 390 μ (average 372)

long by 170 to 230 μ (average 196) wide, tail proper 150 to 170 μ (average 160) wide near anterior end and tapering posteriorly, with the end bluntly rounded Tail cylindrical, immobile, transparent, and structureless except for concentric striae and a few small scattered nuclei in its wall Opening of cercaria chamber elongated A pyramidal mass of tissue arises from base of chamber at junction with tail proper, this supports an attachment for the cercaria body

Cercaria body spindle-shaped, 600 to 780 μ (average 693) long by 195 to 235 μ (average 220) wide Cuticle 1 5 to 2 μ thick, marked by longitudinal and concentric striae, their nature and extent depends on degree of contraction Body provided with sensory tubercles a circle of 10 around oral sucker and one of 6 around acetabulum Besides these, a pair of ventral lateral rows, 4 tubercles in each, extends from oral sucker to the acetabulum, a pair of lateral rows, about 25 tubercles in each, reaches from anterior to posterior end of body, and a pair of dorso-lateral rows, 2 tubercles in each, at level of oral sucker Surface of oral sucker provided with 24 sensory papillae that vary in size and distribution (see Fig 3) Papillae on the oral sucker at sides of stylet are devoid of sensory hairs which are present on the others Limited areas (Fig 3) on both suckers are supplied with sensory hairs 4 to 8 μ long The hairs, aside from those on papillae, confined approximately to outer half of the suckers, except in stylet region of the oral sucker, where they occupy area between level of base of the stylet and mouth opening

Stylet 33 to 37 μ (average 34) long by 8 or 9 μ wide, embedded in a slight anterior prolongation of oral sucker Stylet rounded posteriorly, pointed, and curved dorsally anteriorly, posterior end of stylet somewhat depressed A pair of lateral wings on dorsal side arise abruptly near anterior end, they diminish gradually posteriorly and curve ventrally A slight, short, median keel is present on ventral side of stylet near anterior end Oral sucker 93 to 117 μ (average 105) long by 88 to 96 μ (average 92) wide, with a slight anterior prolongation in the stylet region Acetabulum slightly postequatorial, 122 to 133 μ (average 127) in diameter Ratio of size of oral sucker to acetabulum about 4 5 Penetration gland cells, 6 pairs, indistinct and anterior to acetabulum, mostly intercecal, with ducts having an undulating course anteriorly and opening near tip of stylet Nuclei of gland cells 6 μ in diameter Oral aperture subterminal, esophagus narrow, thin-walled, reaching about

midway of distance between suckers, ceca narrow, poorly developed, terminating near posterior end of body Excretory aperture at posterior tip of body, excretory bladder small, thick-walled, median, with a stem reaching anteriorly almost to acetabulum and then bifurcating to form lateral collecting ducts extending anteriad as undulating tubules to about level of oral sucker The excretory bladder and entire median tubule is surrounded by large, compactly arranged, granular, cystogenous gland cells, with their long axes at right angles to long axis of the body Primordium of genital organs immediately posterior to acetabulum consisting of a poorly developed submedian mass, with narrow lateral prolongations and a thread of cells continuing dorsal to acetabulum as far as its anterior border, indicating the position of the future uterus and genital pore

This description is based on living and on stained and mounted material from *Musculium partumeium* The measurements of the cercaria body were secured from specimens under pressure of the cover glass just before death The following average measurements were obtained from five cercaria bodies killed and then mounted in 10 per cent formalin under slight, if any, pressure body 240 μ long by 135 μ wide, oral sucker 68 μ long by 61 μ wide, acetabulum 79 μ long by 94 μ wide Average measurements of six cercaria bodies, killed in 10 per cent formalin and stained and mounted, were body 205 μ long by 120 μ wide, oral sucker 51 μ long by 45 μ wide, acetabulum 52 μ long by 68 μ wide The following measurements were obtained from a living cercaria moderately contracted and not under pressure body 285 μ long by 145 μ wide, oral sucker 73 μ long by 63 μ wide, acetabulum 75 μ long by 82 μ wide, width of the stylet gland duct area at level of oral sucker 10 μ The cercaria body is full of refractive granules which make it difficult to distinguish the organs The second tubercle in each of the lateral rows is double, the anterior part of the double tubercle is the smaller Doubling is also apparent in the papillae at the angles of the mouth (Fig 3) It was impossible to observe all the stylet gland cells in a single cercaria on account of the refractile material in the body, however, the number of ducts could be determined and the number of cells was obtained by counting the ducts The primordia of genital organs are practically imperceptible in living cercariae, but could be observed in stained and mounted specimens Of the intra-

vitam stains used in this study only gentian violet and neutral red were of value

As already indicated, the tail is almost structureless and seems to be nothing more than an elongated sac, being sticky, this structure is easily tangled up in débris or in any organic material which the snail may eat The cercaria body is relatively inactive in its capsule in the tail, in its resting position the body may be contracted and straight, or elongated with the anterior end folded ventrally The cercaria body may be forced out from the tail by a slight amount of pressure of the cover glass, all the specimens used in the study were obtained in this way In no specimen has the cercaria body been found attached to the tail, although a tissue structure in the bottom of the capsule indicates that it is attached at some time, a condition which prevails in immature cercariae in the sporocyst

Metacercaria

Shape of the body and position and distribution of tubercles and papillae as in cercaria Sensory hairs on suckers absent Longitudinal and transverse striae on body quite prominent, owing to subcuticular musculature Body 485 to 835 μ (average 682) long by 150 to 240 μ (average 208) wide Stylet absent, but its cavity in oral sucker is prominent Remnants of stylet gland-cell bodies and ducts usually present Oral sucker 80 to 130 μ (average 109) long by 82 to 116 μ (average 104) wide, with a slight anterior prolongation marking place where cercaria stylet had been embedded Acetabulum 112 to 165 μ (average 142) long by 112 to 165 μ (average 144) wide, slightly postequatorial Ratio of oral sucker to acetabulum 3 4 Oral aperture subterminal, esophagus narrow, rather thick-walled and reaching to near midway between suckers, there bifurcating to form well-developed, thick-walled ceca which terminate near posterior end of body Cercaria bladder and median collecting tubule dilated to form large excretory bladder (Fig 6) containing numerous clusters or rosettes of very fine refractile granules fixed to its wall Cystogenous glands, surrounding the bladder, much reduced and in various stages of disintegration Wall of excretory duct muscular and terminating in a median pore at posterior end of body Primordia of genital organs somewhat more developed than in the cercaria One of the largest metacercaria, in addition to the anteriorly directed thread of cells as described for the cercaria, showed

a pair of cell threads that extended posteriorly, one on either side of the excretory bladder, one of these cell threads showed enlargements, primordia of testes

The metacercariae on which the description was based were laboratory-raised and -infected snails, *Helisoma antrosa,* which had been infected for at least two weeks The metacercariae do not differ essentially from the cercariae bodies except in size and excretory bladder

The measurements of metacercariae under different conditions are given in the following table

TABLE I

MEASUREMENTS OF METACERCARIAE IN MICRONS

Number of specimens	Body length			Body width			Oral sucker						Acetabulum					
							Length			Width			Length			Width		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Five at time of death under pressure of cover glass	760	835	810	220	240	233	120	130	124	108	116	112	155	165	160	155	165	160
Three killed and mounted in 10 per cent formalin	370	425	397	155	184	169	76	90	83	70	76	73	94	104	99	100	110	105
Four, stained and mounted after being killed in 10 per cent formalin	290	345	309	95	140	113	45	72	61	50	56	53	65	75	70	58	80	70

A metacercaria measured in 10 per cent formalin was 370 μ long by 155 μ wide, its oral sucker was 76 μ long by 70 μ wide and its acetabulum 94 μ long by 100 μ wide When stained and mounted the same specimen was 305 μ long by 118 μ wide, its oral sucker was then 62 μ long by 52 μ wide and its acetabulum 65 μ long by 76 μ wide

The cercaria stylet is discarded intact except that the more delicate wing parts of the structure may be fragmented The stylet may be recovered from the cyst In the fully developed metacercaria the excretory bladder is very much distended and contains clusters of granules adhering to the wall

The encysted metacercariae in naturally and experimentally infected snails, as previously indicated by the writer (Krull, 1933*b*), were usually localized in tissues surrounding the intestine at the level of the heart and were easily freed in dissections, when numerous, several were usually clumped together The majority of cysts are spherical, some are suboval The roomy cyst usually consists of two parts, an inner thin, transparent, and hyaline part of metacercarial origin, and an outer granular, pigmented, and ill-defined part of host origin Cysts of twenty-one metacercariae at least two weeks old, which were devoid of the poorly defined part of host origin, were 200 to 245 μ (average 217) in diameter Subsequent measurements of a few older cysts from experimental and natural infections indicate that the maximum size may be somewhat greater Seven hyaline cysts from a naturally infected snail were 255 to 289 μ (average 277) in diameter

EXPERIMENTS

Remarks concerning experiment animals

The small clams, *Musculium partumeium*, used as a source of material for infection experiments were collected in a small pond near Beltsville, Maryland From September 1 to October 24, 1933, 152 specimens were collected, of this number 11 were actively shedding cercariae

The snails, *Helisoma antrosa*, used in the experiments, were from one fourth to three fourths grown, they were hatched and raised in the laboratory The stock from which the snails were reared was collected in August, 1932 The snails laid eggs the following spring, and when a sufficient number of egg masses had been laid the parent snails were removed The snails which hatched from the egg masses were the ones used in the experiment A control was not considered necessary, since the snails were raised from eggs in the laboratory, nevertheless, twenty specimens from the aquarium that contained the snails to be used in experiments were dissected and found to be negative for any trematodes

The tadpoles of *Rana clamitans* and *R catesbeiana* were collected during May and June, 1933, in a small pond on the Zoological Division Field Station, Beltsville, Maryland, and were kept under laboratory conditions until they transformed The frogs were then kept out of doors in wooden pens covered with metal lath Meat was

placed in the pens to attract flies, which served as food for the frogs The frogs used in experiments were infected during the summer and taken indoors in September The control frogs, forty-five green frogs and twenty-six bullfrogs, raised under conditions identical with those used in the experiments, were examined and found to be negative for trematodes of all kinds Other tadpoles similarly handled had been taken previously from this pond (Krull, 1933*a*), and similar negative results were obtained when they were examined for trematodes

Extensive collections of fish, dragon-fly and damsel-fly nymphs, tadpoles, and cyclops have been negative for flukes, and no fluke-infested animals have ever been traceable to this pond No mollusks had ever been taken in this pond during the first two years of collecting, but in October of the third year a few snails, *Pseudosuccinea columella*, were found A thorough examination of the pond showed the snails to be localized in a small area near the boat with which they had probably been introduced accidentally The water in the pond has an average yearly pH of 6 2

All the mollusks used in the experiments were identified by Mr Wm B Marshall of the United States National Museum

Infection experiments with the second intermediate host

Though several experiments of a similar nature have been carried out, only the most important and significant ones will be described

In one experiment five clams, *Musculium partumeium*, which were actively shedding cercariae, were put in a small stender dish containing water and allowed to stand overnight, since it had been found that cercariae, apparently, were shed only at night Numerous cercariae were observed in the container on the following morning, and eleven immature specimens of *Helisoma antrosa* were then introduced, a pinch of calcium carbonate, of which the snails were fond, was added at the same time for the purpose of inducing them to eat After four days had elapsed, the clams were removed and preserved for identification, and the snails were transferred to a larger aquarium until examined Since these infected snails were usually fed to frogs after a few cysts had been dissected out for study, usually no attempt was made to count the total number of cysts in each snail All the snails became infected and the number of cysts in each snail ranged from one to forty-eight The snails were ex-

amined six to twenty-six days after they had been subjected to infection and five of them died during the time interval Control snails from the same lot were kept in aquaria and under conditions similar to those used in the experiments, none of these died Consequently, there is reason to believe that the infestations were a contributing factor in causing the deaths of the infested snails

In another experiment fourteen cercariae were introduced into a small stender dish containing a pinch of calcium carbonate and a snail Twenty-five minutes later seven cercariae had disappeared The snail was then carefully dissected to determine the position of the ingested cercariae One of the cercariae recovered had encysted near the heart and in this one only the hyaline cyst of cercaria origin had been formed, two others in the same location had not encysted, and the remainder, which had escaped from their tails, were very active in the posterior end of the esophagus The place where the cercariae escaped from the digestive tract was not determined definitely, however, the foregoing experiment showed that the cercariae were eaten and that they had in all probability penetrated the esophagus

Infection experiments with the definitive host

Five green frogs, *Rana clamitans*, and five bullfrogs, *R catesbeiana*, all raised under controlled conditions, were subjected to infection with the metacercariae collected from the laboratory-raised and -infected snails The frogs were infected at different times when metacercariae were available, and since the body of the snail also was usually fed, the exact number of cysts given at one time could not always be determined, but an estimate of the number was always made

Only one of the five green frogs was negative, this was probably the result of giving it the cysts from a snail which had been dead for some time Three of the five bullfrogs were negative, two of these frogs had been given cysts from snails which had been dead for some time, the remaining frog had been given only four encysted metacercariae On the basis of a rough estimate derived from this infection experiment, it appears that about one fifth of the number of metacercariae fed to a frog may be recovered from the bladder upon subsequent examination

Immature and mature flukes were recovered from the frogs infected in the experiment Some of the flukes matured in twenty-

one days, and all completed most of their growth in somewhat less than two months when kept at summer temperatures Five was the largest number of flukes recovered from a single experimental host In two frogs which were given encysted metacercariae at two different times, at an interval of fifteen days, two distinct sizes of parasites were present

DISCUSSION OF THE DEVELOPMENT IN THE DEFINITIVE HOST AND OF THE IDENTITY OF *GORGODERA AMPLICAVA*

Changes take place in the metacercaria very soon after it arrives in the bladder of the definitive host The ratio of the sucker sizes changes on account of the more rapid growth of the acetabulum, the ratio of size of oral sucker to that of acetabulum becomes 1 2, and this ratio is maintained until maturity, when it changes slightly, being about 1 2 4 The sheath around the acetabulum is well developed in flukes before they mature, and the space between the acetabulum and the body proper is very pronounced (Figs 7–8) The vitelline mass on either side of the body soon differentiates into follicles which, apparently, become increasingly distinct until the parasite reaches maturity The ovary increases in size and is more or less trilobed owing to rather shallow indentations of its wall The most conspicuous change takes place in the testicular mass, the right and left portions grow posteriorly and fill the intercecal part of the body posterior to the acetabulum, covering the ovary dorsally In stained and mounted specimens the dense testicular mass shows little evidence of being subdivided into testes, and there is little separation into a right and a left part until maturity As soon as eggs fill the uterus, the spaces in the testicular field become occupied with coils of the distended uterus, the coils show a tendency to separate the testes The testes appear rough in outline and relatively smaller, if not actually smaller, than those in immature flukes, in old, fully grown specimens the individual testes are seen with difficulty The characteristics of the immature fluke are shown in Figure 7, which is of a specimen 600 μ long and 10 days old, and in Figure 9, of a specimen nearing maturity, 900 μ long, and 19 days old

The following measurements were taken from three specimens 19 days old which were fixed in corrosive acetic, then stained and mounted length, 750 to 900 μ (average 853), diameter of oral sucker,

135 to 158 μ (average 146), diameter of acetabulum, 275 to 315 μ (average 298) The youngest mature fluke, which was very similar to the one represented in Figure 9, was fixed in corrosive acetic while under slight pressure, then stained and mounted, after which it measured 850 μ long, the 2 eggs in the uterus were 18 μ and 15 μ long by 13 μ and 11 μ wide The following measurements were secured from four stained and mounted mature flukes, at least 40 days old, in which the uterus, apparently, had reached maximum development length, 2 07 to 3 27 mm (average 2 72), diameter of oral sucker 260 to 330 μ (average 293), diameter of acetabulum, 606 to 785 μ, (average 694) Twelve eggs, 3 from the terminal part of each uterus, were 34 to 37 μ (average 35 5) long by 22 to 25 μ (average 23) wide Three eggs, from one of the specimens, were 43 to 49 μ (average 47) long by 31 to 34 μ (average 33) wide Eggs contain fully developed miracidia when they escape from the parasite

The largest specimen of this fluke collected by the writer is 4 0 mm long and was taken from a naturally infected bullfrog

Harwood (1932) has shown that there are no differences between *G amplicava* Looss, 1899, and *G circava* Guberlet, 1920, and, consequently, considered the latter a synonym, which view is shared by the present writer The writer's specimens agree very well with the description as given by Guberlet, except that the eggs are somewhat larger

SUMMARY

The life history of *Gorgodera amplicava*, as determined by controlled experiments, is as follows The clam *Musculium partumeium* Say was determined as a first intermediate host, the snail *Helisoma antrosa* as the second intermediate host, and the frogs *Rana clamitans* and *R catesbeiana* as definitive hosts of the fluke The experimental evidence for this life history is given In these experiments the snails and frogs were raised and infected under controlled conditions, the clams were naturally infected All the hosts reported have been observed to harbor natural infections also The principal stages in the life history of the parasite have been described

Division, Bureau of Animal Industry
United States Department of Agriculture

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EXPLANATION OF PLATE CIX

Gorgodera amplicava

All drawings either made with aid of camera lucida or based on camera lucida drawings

Fig 1 Flame cell from sporocyst

Fig 2 Cercaria

Fig 3 Cercaria body with penetration glands and collecting tubule of excretory system shown only on one side

Fig 4 Stylet, ventral view

Fig 5 Stylet, lateral view

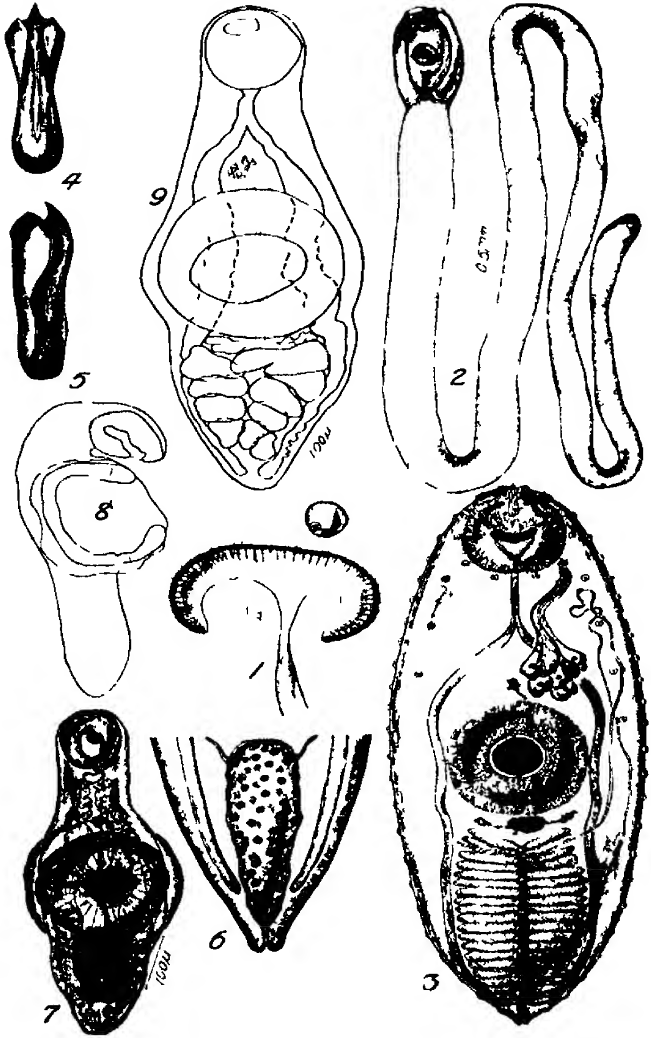
Fig 6 Metacercaria, posterior end, showing excretory bladder and ends of ceca

Fig 7 Dorsal view of immature specimen, 10 days old

Fig 8 Lateral view of immature specimen, 10 days old, showing oral sucker and acetabulum with sheath surrounding it

Fig 9 Ventral view of immature specimen, 19 days old

PLATE CIX



Gorgodera amplicava

SIX UNPUBLISHED LETTERS OF CHARLES DARWIN

WILLIAM E PRAEGER

IT WOULD seem that to biologists all letters of Charles Darwin would have an interest of their own even if the contents are of slight importance I therefore presume to present these letters With the exception of one which was published in a local paper, none of them seems to have been printed They are all addressed to Robert Patterson of Belfast, Ireland, and are preserved in his family He was Darwin's senior by seven years He died in 1872, ten years before his honored friend

When in Belfast a few years ago I saw the originals of the letters and made copies of them I also had the privilege of reading some of Patterson's letters written to his home folks Those telling of meetings of the British Association are especially interesting to a naturalist Scientists whom he met were often mentioned, and in one letter — addressed to Mrs Patterson – he tells of a conversation with Darwin at the rooms of the Linnaean Society The letter also shows the high estimation in which Patterson's textbooks were held by his contemporaries

LONDON 11 Oclock Tues night
May 2 1854

DEAREST MARY

I am just home from the meeting of the Linnaean Society At the dinner of the Linnaean Club, at the Freemason Tavern, I met A B Ward, Lieut Holman, Mr Yarrell, Mr Spence etc It was very pleasant but I was put forward a little more prominently than I would have chosen. I was placed at dinner at the right hand of the President, Professor Ball, and when he proposed the health of the visitors he coupled my name with the toast "as one of the great, if not the greatest benefactor to Natural History in these kingdoms" So I had to make a little bit of a speech Mr Spence had a cab, & he took Van Voorst, Yarrell, & myself to Soho Square, where the meetings of the society are held There I had some pleasant chat with Charles Darwin & Adam White, Curtis the entomologist etc Many were the compliments bestowed on the "Zoology for Schools" I walked home, a distance of a couple of miles, – the night being fine — a member of the Linnaean whom I did not know was my companion

So goodnight

ROBERT PATTERSON

Robert Patterson, Fellow of the Royal Society, was one of the many distinguished amateurs whom Britain and Ireland produced in the nineteenth century When a boy he was apprenticed to his father's business, that of hardware merchant, he became a successful business man and was prominent in civic affairs, filling positions of trust and responsibility in his native town Yet in spite of a life devoted to merchandizing he found time to develop his very decided literary and scientific tastes and was known far beyond his home town as a writer and a lecturer In 1838 he published *The Natural History of Insects Mentioned in Shakespeare's Plays*, a quaint and interesting little book that ran through several editions In 1839 he attended for the first time a meeting of the British Association at Birmingham A long letter telling in detail his impressions of English scientists is still preserved At this meeting he was elected one of the secretaries of Section D, Natural History, his associate was Edward Forbes He held the position for five years About this time he took a leading part in the movement to have the study of natural history introduced into the schools of Ireland This was successful, but a difficulty soon appeared, there were no books suitable for school instruction Patterson attacked the problem and in 1846 published Part I, "Invertebrates," of his *Zoology for Schools* Part II, "Vertebrates," appeared two years later The book was adopted by the commissioners of schools for Ireland and later by those for England and was used for many years The following letter from Darwin will now be understood

DOWN, FARNBOROUGH, KENT
April 17th [1847]

DEAR SIR

I received only yesterday your note of the 9th of March & very kind present I fear you must have thought me ungrateful not sooner to have acknowledged your kindness, but owing to not having sent to the Geological Society for some time, the parcel lay there

I admire your volume much, you seem to have condensed a wonderfully great deal of accurate information & the woodcuts are capital I am very much pleased to hear that the Commissioners of Education have adopted your book, and I hope you may live to see some good naturalists spring up, who will acknowledge your work as their first guide and incitement I beg to thank you for your kind expressions towards me in your note, I remain, dear Sir, with much respect

Your obliged and faithful serv

C

To

R PATTERSON ESQ

In 1852 the well-known zoologist, Wm Thompson, died suddenly after three volumes of his *Natural History of Ireland* had been published Patterson was one of his literary executors, and on him fell the responsibility of completing and seeing through the press the fourth and last volume, issued in 1856 It is evident that Thompson had lent Darwin material to be used in the preparation of his well-known *Monograph of the Sub-Class Cirripedia*, hence, in reply to inquiries from Patterson, the two following letters

DOWN, FARNBOROUGH, KENT
Ap 6th [1854]

MY DEAR SIR

A sharp attack of unwellness has prevented my answering sooner your note of the 28th ulto — Mr Thompson sent me all his M S on Cirripeda & the whole of his collection, which filled a good sized box I remember not long before his death returning all the M S & I feel almost sure I remember packing up all the specimens I have looked in every likely place and can find none of his, but it is just possible that amongst the numbers sent me from various quarters, his may be overlooked In the middle of summer or early autumn I intend returning every specimen which I have borrowed & shall then without fail discover whether I have any of your poor friends yet here And in that case will communicate with you — But I very strongly think that collection was returned This instant my memory flashes across me that he at my request returned me one specimen for further examination (and which one I must somewhere have) but this demonstrates that the main collection had previously been returned to him

Pray forgive this long note & believe me Dear Sir

Yours sincerely
C DARWIN

DOWN FARNBOROUGH KENT
Aug 21 [1854]

DEAR SIR —

I have now gone through all the cirripedes in the house, and I find some half dozen specimens (including some bottles) belonging to poor Thompson None of these are of much value, excepting as being (at least some of them) rare as Irish

I have also a few M S notes Will you be so kind as to say how I shall send them They are rather too heavy & being glass not fit to go by post and they are not worth the carriage of so long a journey Is there anywhere in London where they could lie till other objects accumulated? I am sorry to cause this trouble but would be much obliged if you could send me a line Unfortunately I cannot say positively that I shall be at Liverpool, otherwise that probably would have been a good way of transmitting the specimens

Pray believe me
Dear Sir
Yours sincerely
C DARWIN

Darwin's interest in the variations of rabbits dates from his visit in 1833 to the Falkland Islands, where introduced domestic rabbits had become feral On September 8, 1856, writing to J D Hooker he says

By the way I have been astonished at the differences in the skeletons of domestic rabbits I showed some of the points to Waterhouse, and asked him if he could pretend they were not as great as between species, and he answered, "They are a great deal more" How very odd that no zoologist should ever have thought it worth while to look to the real structure of varieties

On this rabbit problem Darwin asks help from Patterson

Down, Bromley, Kent
March 10th [1857]

My dear Sir

I am going to beg a great and troublesome favor of you, — I have been collecting skeletons of all varieties of Rabbits, & I want very much a real Irish Rabbit, the L veomicule of our poor friend Thompson — Would you have the great kindness to take the trouble to procure me one The only care requisite to be to get one not very severely shot, but especially not struck on the back of the head to kill it, as that part is easily injured & is very characteristic

I enclose an address, and you will know whether to steamer to Liverpool & then per Railway, will be the cheapest and quickest route — I am fearful you will think me rather unreasonable in begging this favor

Truly believe me
My dear Sir
Yours sincerely
Ch Darwin

The next letter, on the same subject, has been badly mutilated, evidently to obtain the signature

Down, Bromley, Kent
Nov 12 [1857]

My dear Mr Patterson

The rabbits arrived safely last night after their long journey, & most sincerely do I thank you for the very great trouble you have taken to oblige me Externally they seem to differ extremely little except perhaps in fulness of head, from the rabbit of this neighbourhood But they shall be skeletonised

I have now rabbits from Shetland, Madeira & Ireland and hope to receive one soon from Jamaica, so I shall have good means of comparison for to several domestic breeds

If you remember whenever you see Lord Massarene I hope you will present my thanks for his great kindness — When I have done with the Rabbit Skeletons for my own purpose I shall present to the Brit been thrown away & I well know that you work for Natural History from a pure love of Science

With my very sincere thanks pray believe me

The results of this work appear in *Animals and Plants under Domestication*, published eleven years later

Letter six is unimportant, but being brief may well be included here It was written about a year after the publication of the *Origin* It suggests the struggle for existence

DOWN, BROMLEY, KENT
Oct 21 [1860]

MY DEAR SIR

I [would] like to thank you for so kindly taking the trouble of communicating the Rat V Rabbit case I am very glad to have all such facts, but it is doubtful whether I would require to use it so I will not give trouble to your informant of inquiring

With many thanks, prey believe me my dear Sir

Yours sincerely

CH DARWIN

Robert Patterson had a wide circle of friends among the scientists of his day He was an active correspondent and must have received many letters from men of note, but, with the exception of these six, none seems to have been preserved That there were others from Darwin is very probable, for there seems to have been a genuine friendship between the two naturalists, but none is known or likely now to be discovered

KALAMAZOO COLLEGE
KALAMAZOO, MICHIGAN

BIOLOGICAL STUDY OF THE WALNUT HUSK FLY (*RHAGOLETIS SUAVIS* LOEW)*

DONALD T RIES

DURING the fall of 1931, while collecting black walnuts (*Juglans nigra*) near Pinckney, Livingston County, Michigan, the writer found a large number having the husks darkened and apparently rotted The husks were blackened and very slimy inside and contained a large number of whitish maggots that moved freely through the rotted pulp Infested nuts were very disagreeable to handle, since the blackened husks stick to the inner shell of the nut Inasmuch as the fruit of the black walnut is not important to any extent commercially in this section, this insect has not attracted any special attention, and very few people, even those familiar with the maggots, have ever seen the adult fly

This species belongs to the order Diptera and the family Trypetidae It was first described by Loew from a male received in 1862 from "the middle states"

In Michigan the black walnut (*Juglans nigra*) and the butternut (*Juglans cinerea*) are the only hosts of this insect In other parts of the country it has been reared from the husks of Persian walnut (*Juglans regia*) and Japanese walnut (*Juglans sieboldiana*) By far the commonest host in Michigan is the black walnut

The husk fly occurs throughout the range of its host plants in this state Both the black walnut and the butternut occur throughout the southern counties of the Lower Peninsula

The emergence of the adults from the ground depends largely upon the temperature that has accumulated during the pupal period in the ground In the spring of 1932 the first emergence in this vicinity was on July 20 During that season adults continued to emerge until September 26 The peak of emergence was during the first ten days of August Table I gives the number of emergences in one of the large outdoor cages during 1932

* Scientific contribution No 4 from the Cranbrook Institute of Science

TABLE I

Dates and Number of Emergences of Adults from the Ground in 1932

es		No of emergences	Dates		No of emergences
July	20	1	Sept	9	3
	28	5		10	2
	31	8		11	5
Aug.	1	3		17	3
	2	12		23	1
	6	6		24	1
	9	7		26	2
	15	8	Oct	10	First larvae left husks
	23	First oviposition observed		14	First larvae pupated
	30	9			
	31	First newly hatched larvae found			

We see from this table that the emergence period covered 69 days in 1932

In 1933, however, the first emergence was observed on June 19, and emergences continued throughout the season until September 24, thus giving an emergence period of 98 days The peak of the emergence during 1933 was near the end of June The 1933 emergences are given in Table II

Although the first emergence in 1933 was a month earlier than it was in 1932, the date of oviposition remained about the same, vis August 22 in 1933 as compared with August 23 in 1932 This is probably explained by the fact that oviposition cannot take place until the husk of the nut becomes soft enough for the insertion of the ovipositor During the latter part of July, 1933, the writer observed a number of females endeavoring to oviposit, but they seemed unsuccessful in their attempt to insert the ovipositor through the tough exocarp According to observations made by him during the past season, the green exocarp increases in hardness as the nut develops, reaching a maximum hardness about the 20th of August As the season progresses after this time the husk gradually softens, and we find that oviposition takes place during this period of decreasing hardness Boyce found that oviposition in Eureka walnuts by *R completa*, a closely related species, is inhibited until a hardness approximating 1,300 grams per square millimeter is reached

Results of two years' experiments in this state tend to show that

TABLE II

DATES AND NUMBER OF EMERGENCES OF ADULTS FROM THE GROUND IN 1933

June	19	2	Aug	2	1
	20	3		3	1
	21	8		4	1
	22	2		5	2
	25	1		6	1
	27	2		13	2
	28	11		15	3
	29	20		16	4
	30	4		17	5
July	3	6		19	2
	5	9		20	2
	6	3		22	First oviposition observed
	10	6		25	4
	12	2		28	3
	14	3		31	First larvae hatched
	16	4	Sept	2	2
	17	5		3	1
	18	8		5	4
	20	1		10	1
	21	4		15	5
	22	3		24	7
	25	8	Oct	6	First larvae left husks
	27	3		11	First larvae pupated
	29	3			
	31	5			

the accumulation of warm temperatures during the dormant pupal period has a definite effect on the emergence of the adults in the early summer These experiments have not been completed and reports on them will, therefore, not be included in this paper, but will be published at a later date

The adult flies, when confined to large cages, fed freely upon sugar water and seemed to act normally, like those on the trees. However, the writer was unable to attract any flies to several types of bait pails hung in the trees

The adults (Pl CXI, Fig 1) of this species are the largest in the genus, measuring from 5 to 7 mm Cresson gives the following description of the adults "Body color tawny to ferruginous Scutellum, apices of second to fourth abdominal segments, and legs paler, yellow Bases of entire fifth abdominal segment of male somewhat

darker Wings with veins in hyaline areas toward the costa whitish, in the other parts, brown The median hyaline triangle does not extend beyond fourth vein but the hyaline spot in the apex of third posterior cell sometimes extends into the discal cell" The head, sides, and upper portion of the abdomen, as well as the legs, are covered with a more or less heavy coating of brownish hairs The dorsum of the thorax is densely covered with short yellowish hairs interspersed with a few long stiff brown bristles The male genitalia are figured in Plate CXI, Figure 3

During the preoviposition time the flies rest quietly on the leaves for long periods, or make short flights from one leaf to another At this time they seem to be lapping food from the surface of the leaves The writer observed similar actions in the adults of *Rhagoletis pomonella* Walsh

As oviposition time approaches both the males and the females show a tendency to cluster about the fruit and to become very much more active Both sexes flit nervously from nut to nut The male seems to select a particular fruit upon which he takes his stand, he fights off any other males that may approach during the time he is waiting for a female to appear When he alights on a nut already occupied by another male, the first occupant immediately attacks him The two face each other, rear up on their hind legs, and engage in a brief but often amusing bout The victor, usually the first occupant, holds his position while the intruder flies away

When ready to oviposit the female approaches the fruit by half flying, half crawling along the leaves near by before alighting on the nut itself As she approaches, the male becomes more and more excited, making short quick jerks back and forth, spinning around and moving the wings rapidly up and down When she alights and finds a suitable place in which to oviposit — either a green area or a hole made by a previous ovipositing female — she inserts the tip of the abdomen The male immediately springs upon her and copulation takes place This lasts from a few seconds to several minutes. There are alternate periods of copulation and oviposition There may be five or six such periods before the female flies away How many eggs are laid at each oviposition is not determined Several times it was noted that the male remained mounted while oviposition took place

A number of punctures in the fruit were made by the author

with a scalpel or a needle The males invariably guarded these, apparently considering them suitable places for the female to oviposit Even after the female had oviposited and left, the male continued to stand guard Several times the males were observed consuming the juice that was discharged from these openings Many times both the artificial and the natural punctures, in which eggs had already been laid, were revisited by ovipositing females This probably accounts for the fact that a hundred or more eggs are not uncommon in a single puncture The eggs are laid in closely compressed masses (Pl CXII, Figs 1-2), usually from 2 to 3 mm beneath the outer skin of the husk

As has already been mentioned, the nuts are well developed by the time oviposition takes place The place of oviposition is in the green portion of the husk and is usually difficult to determine unless a drop of the dark juice that usually seeps out from the oviposition puncture has run down and stained the husk of the nut More often, however, the first sign of infestation does not show until the eggs have hatched and the larvae begin tunneling Within several days after the larvae begin feeding the place of attack shows as a blackened area on the surface This spot rapidly increases in size as the larval burrows penetrate more of the tissues

Inasmuch as newly hatched larvae were observed in the same channels with larvae at least a week old, it would seem that the female does not always oviposit in a new puncture

The discoloration and breaking down of the husk tissue (Pl CXII, Figs 3-4) is limited to the portion where the larvae are burrowing A number of nuts were found with half of the husk blackened and the tissues broken down, but the remaining portion was the clear whitish color of an uninfested husk

The egg of this species is white, banana-shaped, and distinctly curved It is 0 85 to 1 0 mm in length and about 0 2 mm in width Both ends taper One end terminates in a rounded point, the other, in a small but distinct spur The eggs hatch in eight to ten days The writer has found from 10 to 150 in a single puncture Brooks reports having found nearly 200 in a single puncture

The larvae feed until after the first frosts in the fall, when they make their way into the ground They usually leave the husks three or four days after the nuts fall to the ground The larval period lasts from 35 to 40 days A number of live and active larvae have

been found in the husks of nuts during the latter part of November, but whether or not these are able to survive the winter and complete their life cycle has not been determined

The larvae (Pl CX, Fig 1) are creamy to white and measure, when mature, from 8 8 to 10 0 mm in length and from 1 7 to 2 0 mm in width They have eleven segments of nearly equal length in addition to the head segment A distinct fusiform area (Pl CX, Fig 2) is on the anterior portion of segments 3–11, with traces of a similar area on segments 1–2 The head is small, bearing two prominent tubercles that seem to be surmounted by two chitinous elevations on each There are also two small chitinous-tipped antennae at the base of each mouth hook A definitely ridged area is noticeable on the head segment immediately below the mouth hooks

The anterior spiracles (Pl CX, Fig 2) are small, yellow, and chitinized, with 22–26 small rounded tubules arranged in three irregular rows The posterior spiracles (Pl CX, Figs 3, 5) are small and are located just above the medio-horizontal line, each spiracle has three quite broad yellow entrances, with a darker yellow peritreme The button is small and slightly elevated Posterior spiracles are on a definitely elevated area The mouth hooks (Pl CX, Fig 4) are definitely curved, black, and pointed

Most of the larvae emerge through a single hole in the side of the husk or near the blossom end They work their way four to seven inches beneath the surface and pupate two to four days after leaving the fruit Only a few larvae pupate in the husk

The pupae (Pl CXI, Fig 2) are of a honey-yellow color and cylindrical and taper from the middle toward the ends The size varies from 3 3 to 5 16 mm in length, averaging about 4 5 mm , and from 1 55 to 2 27 mm in width, averaging about 2 07 mm They have eleven visible segments, with shallow, yet distinct, intersegmental grooves The pupae bear a close resemblance to kernels of wheat

A number of nuts that were placed in pans and cages in October were found to contain extremely young, first instar, larvae These had apparently hatched only a few days before and it was doubtful whether they were able to reach maturity before being killed by the heavy frosts in November The nuts had been collected on October 2 Observations made in the field about September 22 revealed adults still ovipositing in the husks

That a small percentage of the pupae hold over and emerge the second season was shown by the fact that about 6.8 per cent of the pupae in the cages during the winter of 1931–32 failed to emerge during 1932. They were held over the following winter of 1932–33. During July, 1933, 4.3 per cent of the 6.8 per cent emerged as adults. This delayed emergence checked very closely with results of experiments carried on by the writer in this state during 1925–27 in *Rhagoletis pomonella*.

The writer is indebted to Mrs. Elizabeth Burckmyer of Cornell University for the drawings.

CRANBROOK INSTITUTE OF SCIENCE
BLOOMFIELD HILLS, MICHIGAN

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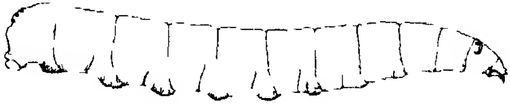
PLATES CX–CXII

PLATE CX



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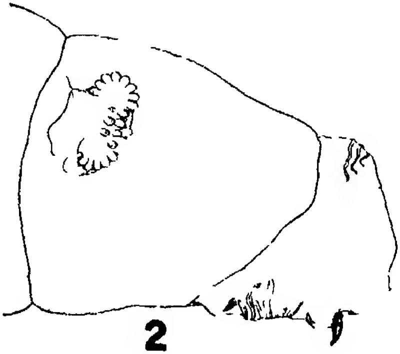

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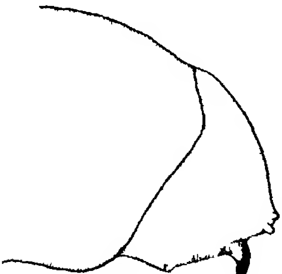

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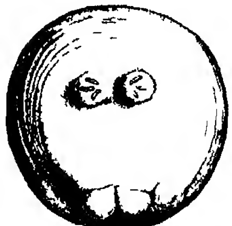
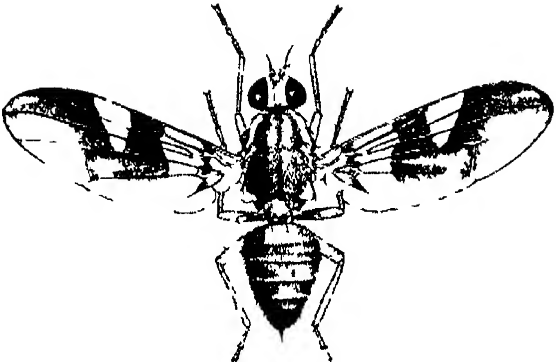


5

Fig. 1. Lateral view of larva of *Rhagoletis suavis*
Fig. 2. Head segment showing anterior spiracles
Fig. 3. Enlarged posterior spiracle
Fig. 4. Head segment showing mouth hooks
Fig. 5. Caudal end of larva showing posterior spiracles

PLATE CXI



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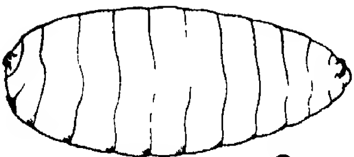

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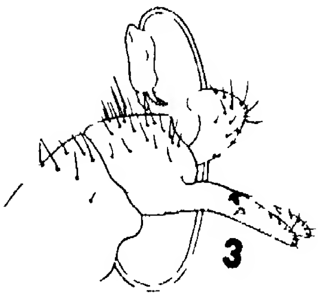

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Fig. 1 Adult ♂ *Rhagoletis* [illegible]
Fig. 2 Lateral view of pupa
Fig. 3 genitalia (lateral view)

PLATE CXII

1

2

3

4

Figs. 1–2. Eggs of *Rhagoletis suavis* in husk of walnut (courtesy of United States Department of Agriculture).

Fig. 3. Walnut husk broken open to show (*a*) infested portion and (*b*) uninfested portion.

Fig. 4. Infested walnut husk broken open to show larvae feeding.

STUDIES ON THE FEMALE REPRODUCTIVE SYSTEM OF THE PRAIRIE DOG *CYNOMYS LEUCURUS* *

I GROSS MORPHOLOGY

ALFRED H STOCKARD

INTRODUCTION

THE biology of the female reproductive system has long claimed the attention of zoölogical investigators The relation of this system to the ever-absorbing problem of the origin of the individual, its striking and profound anatomical and physiological cyclic changes, the seeming maze of interrelations between its physiology and endocrine physiology, and the apparent lack of uniformity in the behavior of the system in the several species of mammals have all served to hold attention

In previous papers the author has outlined the reproductive and the seasonal activities of the prairie dog (1929, 1930) This paper deals with the gross morphology of its female reproductive system and the cyclic changes in the adult animal

The author is indebted to Professor Peter Okkelberg for his direction and assistance in the course of this work

HISTORICAL

Investigations of the mammalian female reproductive system date back to the beginning of medical and zoölogical research Aristotle makes numerous references to the vagina and cites previous writings on the subject He named and described, although incorrectly, the uterus and the os uteri Correct observations on the functions of the ovaries of mammals were first recorded by Vesalius (1543), they were later studied by Fallopio (1561), Fabricius (1625),

* Contribution from the Zoölogical Laboratory of the University of Michigan

and Harvey (1650) Vesalius was also the first to interpret correctly the structure and function of the oviducts

Within the ovary the corpus luteum was discovered by Coiter (1573), and the Graafian follicles, though seen previously, were first described by Steno (1667) and later more fully by De Graaf (1672), who mistook them for ova The true ovum was first described by Von Baer (1827), though Prévost and Dumas are credited by Costé (1834) with its discovery in 1824 The work of Von Baer aroused the interest of morphologists generally in the structure and changes in the ovary A list of investigators of the mammalian ovary since his time would include hundreds of names

PRESENT STATUS OF THE PROBLEM

Though the literature is imposing, the number of species of mammals that have been studied in detail is less than a score, and a complete study of morphogenesis, of the cyclic phenomena of oestrum, of pregnancy, and of the life-cycle of the reproductive system has not been made on any single species Our knowledge of the morphology and the cyclic phenomena is inadequate because of unsatisfactory methods in histological technique, lack of exhaustive investigation of the several problems in any one form, differences in the several groups of animals, and in many cases the insufficiency of the number of animals investigated, and the difficulty of rearing in the laboratory the species in which the phenomena are present in their simplest form Recent advances in mammalian endocrinology in relation to reproduction make it important that our knowledge of the morphology of the reproductive system be extended to new forms in which the patterns of changes are relatively simple

MATERIALS AND PROCEDURE

The prairie dog seemed to be the most desirable form on which to conduct this investigation No work on this form had been recorded in the literature, and the family *Sciuridae*, to which it belongs, has been investigated to only a very limited extent, even though it has a wide distribution and many species, some of which contain numerous and conspicuous individuals that may easily be obtained The prairie dog has many habits which make it an unusually interesting form for study of problems related to reproduction Since it is now the object of a concerted extermination project by rodent-control

organizations, some attempts should be made to determine what other interesting features it possesses

Wild animals were obtained, above ground, by shooting in the vicinity of Laramie, Wyoming, during the springs of 1925, 1927, and 1928, they were sought during the entire year of 1928, though they could be found only between March 27 and July 4 Table I indicates the date of collection, sequence of progress, and stage in the sexual cycle attained by the animal, and the histological preparations made for each animal studied

The reproductive tracts which were later examined microscopically were dissected out complete and fixed, those of the 1925 and most of the 1927 collections immediately in he field and the remaining ones in the laboratory one to three hours after collection In 1925 warm Allen's modification of Bouin's fluid was used, and in 1927 and 1928 Bouin's fluid alone Tissues of the 1925 and 1927 collections were rinsed in tap water after 4 to 24 hours in the fixative, drop-dehydrated to 70 per cent alcohol and stored in a 7 1 2 alcohol-glycerine-water mixture or in paraffin The 1928 materials were transferred directly from the fixative to 70 per cent alcohol after 5 to 15 days The material was embedded in paraffin or paraffin-methylbenzoate-celloidin, sectioned serially, and stained in Heidenhain's haematoxylin and eosin or in Mallory's connective tissue stain after mordanting in Zenker's fluid without acetic acid The 1925 and 1927 technique yielded the most satisfactory results The microscopic technique is recorded here because the sequence of stages was determined in part by histological methods The animals were arranged in the sequence recorded in Table I after a study of the collection record, the gross morphology, and the histology of the reproductive system of each

STRUCTURE

The reproductive system of the prairie dog consists of paired ovaries related in position to paired oviducts which lead into the horns of a duplex uterus, and these open by separate ostia into the vagina, which terminates externally in the vulva The ovary (Pl CXIII, Figs 1, 4) is bean-shaped and variable in size, being usually 4 to 5 mm long, 3 5 to 5 mm wide, and 2 to 3 mm thick It is attached on its hilar (ventro-medial midportion) surface by the mesovarium to the ligamentum latum (Pl CXIII, Fig 4) and is

TABLE I

Records of Collection Date, Sexual Stage, and Histological Preparations of Prairie Dogs Studied

Histological preparations from each specimen are indicated as follows V, sample transverse sections from vagina, U, sample transverse sections from uterus, TO, incomplete serial sections from oviduct and ovary, TOs, complete serial sections of oviduct and ovary

POSITION IN REPRODUCTIVE CYCLE

Specimen	Date taken '25	'27	'28	Histological prep	Specimen	Date taken '25	'27	'28	Histological prep
2503	—			UTO	2714		3-30		VUTOs
2514	—			UTOs	2827			4-4	VU
2504	—			VUTO	2807			3-27	VU
2512	—			UTO	2748		4-9		VU
2513	—			UTOs	2718		3-30		VUTOs
2857			4-14	VU	2713		3-27		VUTOs
2831			4-4	VU	2715		3-30		UTOs
2742		4-5		VUTOs	2716		3-30		VUTOs
					2881			4-22	V

II OESTRUM

2527	—			UTOs	2533	—			UTO
2821			4-2	VU	2522	—			U
2521	—			UTOs	2535	—			UTO

III GESTATION

A. *Period of tubular stages*

2510	—			UTO	2738		4-5		UTOs
2509	—			UTO	2517	—			UTO
2501	—			UTO	2506	—			UTO
2528	—			UTO	2735		4-5		UTOs
2531	—			UTO	2750		4-9		UTOs
2520	—			VUTO	2733*		4-5		UTOs
2505	—			UTO	2534	—			UTO
2734		4-5		UTOs	2876			4-20	VU
2515	—			UTO	2789		4-5		UTOs
2736		4-5		UTOs	2524	—			UTO
2511	—			UTO	2736†		4-5		UTOs
2523	—			UTO	2741†		4-5		UTOs
2508	—			UTO	2766†		4-23		U

* Two-cell stage

† Four-cell stage

B *Period of early uterine stages*

(Sequence determined by relative size of implantation nodes in uterus)

Specimen	Date taken			Histological prep	Specimen	Date taken			Histological prep
	'25	'27	'28			'25	'27	'28	
2820			4–1	V	2813			4–1	VU
2825			4–4	VU	2833			4–4	VU
2543	—			UTO	2746		4–9		UTOs
2532	—			UTO	2751		4 9		UTOs
2822			4–4	VU	2812			4–1	V
2823			4–4	VU	2814			4–1	V
2824			4–4	VU	2536	—			UTO
2826			4–4	VU	2832			4–4	VU
2530	—			UTO	2525	—			VU
2740		4–5		UTOs					

C *Period of later uterine stages*

Specimen	Date taken			Embryo length in mm	Histological prep	Specimen	Date taken			Embryo length in mm	Histological prep
	'25	27	'28				25	'27	'28		
2839			4–10	3	VU	2875			4–20	16	U
2868			4–16	3	VU	2849			4–14	17	VU
2886			4–22	3	VU	2767		4–23		18	UTOs
2889			4–22'	3 5	VU	2862			4–17	18	V
2835			4–10	4	VU	2864			4–17	18	VU
2830			4–4	4 5	VU	28105			5–1	18	VU
2843			4–10	5	VU	2778		4–25		19	UTOs
2842			4–10	6	VU	2887			4–22	20	VU
2870			4–17	6	VU	2846			4–14	23	V
2840			4–10	7	VU	2852			4–14	23	V
2848			4–14	7	VU	2851			4–14	25	VU
2859			4–14	7	VU	2860			4–14	25	VU
2828			4–4	9	VU	2776		4–25		26	UTOs
2858			4–14	10	VU	28101			5–1	28	VU
2877			4–20	10	VU	2878			4–20	30	VU
2837			4–10	11	VU	2544	—			30	UTO
2838			4–10	11	VU	2885			4–22	30	VU
2850			4–14	12	VU	2774		4–25		31	UTOs
2865			4–17	12	VU	2856			4–14	32	VU
2768		4–23		12	VUTOs	2883			4–22	35	VU
2841			4–10	13	VU	2894			4–27	42	V
2782		4–30	•	13	UTOs	2867			4–17	42	VU
2866			4–17	14	VU	2890			4–27	45	VU
2869			4–17	15	VU	2896			4–27	50	V
2884			4–22	15	VU	2895			4–27	55	V

TABLE I (*Continued*)

Specimen	Date taken '25	'27	'28	Histological prep	Specimen	Date taken '25	'27	'28	Histological prep
				IV LACTATION (Sequence determined by relative size of placental remains in uterus)					
28121			5-12	VU	2538	—			UTO
28103			5 1	VUTO	2892			4-27	V
27102		5-7		VUTOs	2898			4-27	VUTO
28128			5-12	VU	2539	—			UTO
2888			4-22	VU	2784		5-7		UTOs
2882			4-22	VU	2789		5-7		UTOs
2541	—			UTO	28111			5 8	VU
28100			5 1	VUTO	28113			5-8	VU
2540	—			UTO	28119			5-8	VUTO
28104			5-1	VUTO	2783		5-7		U
28120			5 8	V TO	2794		5 7		UTOs
2537	—			UTO	28127			5-12	VUTO
28114			5-8	VUTO	2790		5-7		UTOs
				V POST-LACTATION (Sequence determined by relative degree of involution of placental remains and of uterus)					
2818			5-8	VUTO	28137			5-25	VU
28125			5-12	VUTO	28145			6-8	VU
28135			5-19	VUTO	28148			6 8	VUTO
28136			5-19	VUTO	28153			6-10	VUTO
28139			5-25	VUTO	28151			6-10	VUTO
28155			6-10	VUTO	28161			6-23	VUTO
28157				VUTO	28164			6-23	VUTO
28158			6-16	VUTO	28165			6-23	VUTO
28166			7 4	VUTO	28170			7-4	VUTO
2791		5-7		U	2795		5-7		UTOs
28123				VU	28163			6 23	VUTO
28134			5-19	VUTO					
				VI UNCLASSIFIED					
28138			5-25	VU	2501	—			UTO
28143			6-8	VUTO	2502	—			UTO
28171			7-4	VUTO	2519	—			UTO
28175			7-4	VU	2518	-			UTO
28178			7-4	VU	2516	—			UTO
2781b		5-7		U	2526	—			UTO
2749		—		U	2829			4-4	V
2786		5-7		U	28102			5-1	VU
2787		5-7		U	28129			5-12	VU
2775		4-25		U	2770?		—		U
27101		5-7		U					

Total number of specimens studied, 192 (Five unnumbered specimens were dissected after gross preservation in formalin)

inclosed in an incomplete ovarial bursa, studied recently by Agduhr (1927) in the mouse. The ovary is of a smooth and regular contour in young animals, but in sexually mature animals it is subject to constant changes in both size and shape. It is covered by the ovarian epithelium, which is continuous with the peritoneum. On its surface are hillocks of various sizes formed by maturing or recently ruptured follicles and by corpora lutea. These hillocks are separated by grooves and subside upon involution of their contained structures.

The oviduct (Pl. CXIII, Figs. 2, 4) is a firm-walled tube approximately 35 mm. long and 0.75 to 1.5 mm. in outside diameter. Its distal portion, the pars interstitialis, penetrates the mesenterial wall of the uterus and adjoins its lumen near the tip. Its proximal end expands into a corolla-like infundibulum marked by prominent rugae and fimbriae and lies ventro-lateral to the hilar portion of the ovary. The tube is uniform in diameter over the distal 30 mm. of its free length, the isthmus, but is slightly expanded over its proximal (ovarial) 5 mm., the pars ampullaris. From its uterine end the oviduct follows the wall of the bursa, first in a cranio-dorsal direction, then it curves ventrad around the anterior end of the ovary to the floor of the bursa, which it follows across to the medial wall and then it turns sharply dorsad and terminates in the infundibulum which is attached to the mesovarium at the ventro-lateral hilar portion of the ovary. The infundibular opening faces laterally away from the ovary and into the bursa, its fimbriae partly occludes the mouth of the bursa (Pl. CXIII, Fig. 3). This relation of the infundibulum to the ovary holds in all animals taken, regardless of the stage in the sexual cycle. There is no evidence that the ovary is clasped by the fimbriae during oestrum. A series of secondary short curves regularly present eight convexities to the lateral view, the middle six of these curves are sharper than the terminal ones.

Each horn of the uterus is suspended from the dorsal body wall by the ligamentum latum. The two horns are separate over the greater portion of their length, but are together in a common sheath of circular muscle fibers over approximately two centimeters of their posterior portion. The two horns have separate cervices and open into the vagina by separate ostia. The uterine cornua vary in size, shape, and proportions with the phases in the sexual cycle. During dioestrum they have a smooth surface, are circular in cross-section,

and are 2 to 3 mm in diameter (Pl CXIV, Fig 1) and 6 to 8 cm long They are of firm texture and have relatively thick, muscular walls and small lumina Only two regions of the uterus are recognizable externally — the free cornua and the inclosed cervices

As oestrum approaches the uterus increases in length to 10 to 14 cm and in diameter to 4 or 5 mm (Pl CXIV, Fig 3), and its walls become turgid After copulation it is distended by an enormous plug into a thin-walled tube as much as 10 mm in diameter (Pl CXIV, Fig 2) and 20 cm long Upon the loss of the plug the uterus returns to its procestrous size and appearance (Pl CXIV, Fig 3) When the embryos become distributed to the points of future implantation a nodular swelling appears in the uterine wall at each point where implantation will later take place These implantation nodes increase in size until at term they are ovoid bodies with diameters 30 by 55 mm Between the nodes the uterus retains a diameter of 5 to 8 mm , but becomes prominently ridged longitudinally After parturition the entire uterus is flabby and longitudinally ridged, and is enlarged into nodes at the sites of the placentae, which are retained in position and resorbed during the period of lactation The flaccid condition gradually subsides, the nodes decrease progressively in size as the placentae are resorbed, and the uterus returns to its normal resting appearance, though it is much smaller at this time (Pl CXIV, Fig 4) than it is when the animals break hibernation in the spring

The vagina is circular in outline, is relatively thin-walled and possesses a large lumen, which is usually collapsed (Pl CXIV, Fig 5) Its dimensions are approximately 8 mm in outside diameter and 20 mm in length Except during the breeding season it is partly closed at its external end by a closure membrane formed by fusion of the lips of the vulva (Pl CXIII, Figs. 5–6)

Two paired mesenteries, the ligamentum latum and the round ligament, support the reproductive tract The ligamentum latum is a triangular fold of the peritoneum, along whose ventro-caudal border the reproductive organs are suspended The fold is attached along its dorsal border to the hyposkeletal musculature and extends from the level of the kidneys in a caudo-medial direction to the level of the cervix uteri The free (cranio-ventral) border of the ligament slopes toward the ovary, which lies near the ventral angle of the ligament midway between the kidney and the pubic symphysis At this

point the ligament is approximately 8 cm in width, from which it narrows progressively to an apex at the cervix

The ligamentum latum is folded into a pouch, the bursa ovarii mentioned above, which incloses the ovary and the proximal portion of the oviduct The bursa (Pl CXIII, Figs 2–4) is approximately ten times the volume of the ovary and has a mouth about 4 mm in diameter and directed caudo-ventro-laterally, being often partly occluded by portions of the infundibulum and the ovary The ventral border of the ligamentum latum forks into mesial and lateral limbs, the mesial limb being the mesovarium to which the hilar portion of the ovary and the infundibulum are attached (Pl CXIII, Figs 2 4) The lateral limb has embedded in it the remainder of the oviduct Its ventral border is thickened into a system of strong cords, the mesosalpinx, which radiate from the tip of the uterine horn to the several coils of the oviduct and, with the oviduct, support the greater part of the lateral wall of the bursa ovarii (Pl CXIII, Fig 2)

The mesovarium contains a complex system of tubular structures rarely visible macroscopically but conspicuous microscopically in approximately two thirds of the mesovaria The system is composed of tubules, whose lumina vary in diameter up to 20 micra, and of cysts, which sometimes attain a diameter of 2 mm These structures were interpreted as the epoöphoron of Waldeyer (1870) and related structures, and will be further described in a later paper

The secondary or round ligament arises from the lateral surface of the ligamentum latum near the mid-region of the uterine horn and passes directly caudad to the inguinal region of the body wall The ligamentum latum supports the ovarian arteries, veins and lymphatics, and the nerves supplying the reproductive tract It also supports a large amount of fat disposed throughout its structure generally and in a very firm mass just anterior to the ovary

SUMMARY

The gross morphology of the female reproductive tract of the prairie dog, an hitherto unstudied genus belonging to a little studied but very common family of mammals, has been described The description covers gross structural features and cyclic changes, a knowledge of which is necessary before a profitable histological study can be made The species investigated shows unusually pronounced

and sharp seasonal changes and characteristics Many of its morphological and physiological characters are primitive, but some appear to be highly specialized The retention and resorption of the placenta is a character which has not been described for any other form

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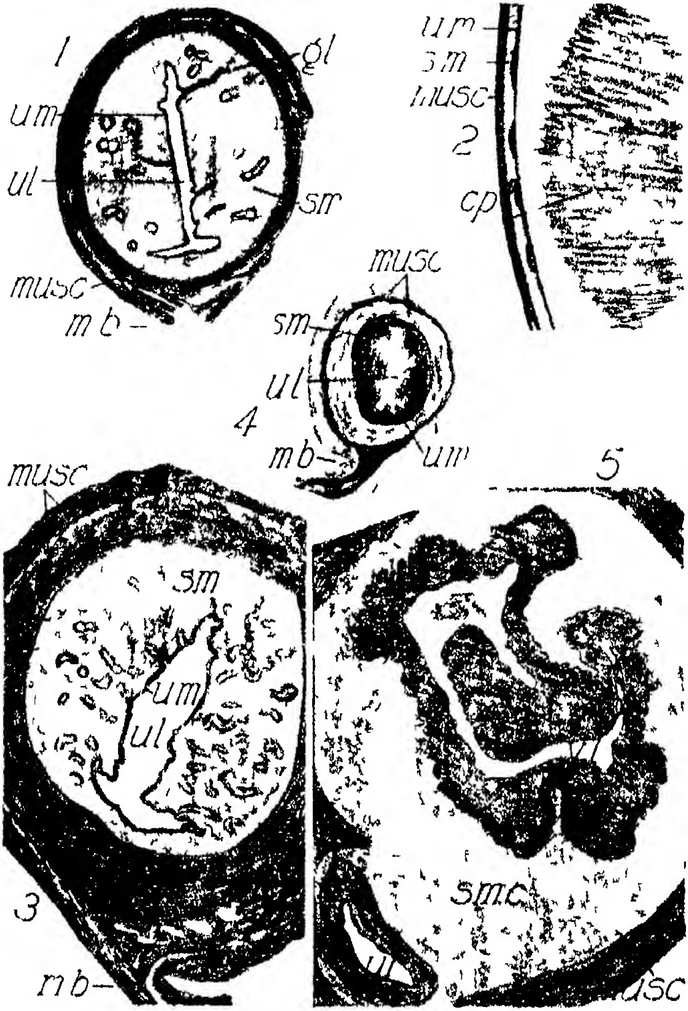
PLATE CXIV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EXPLANATION OF PLATE CXIV

FIG 1 Transverse section of a uterine horn of animal 2503 taken in prooestrum

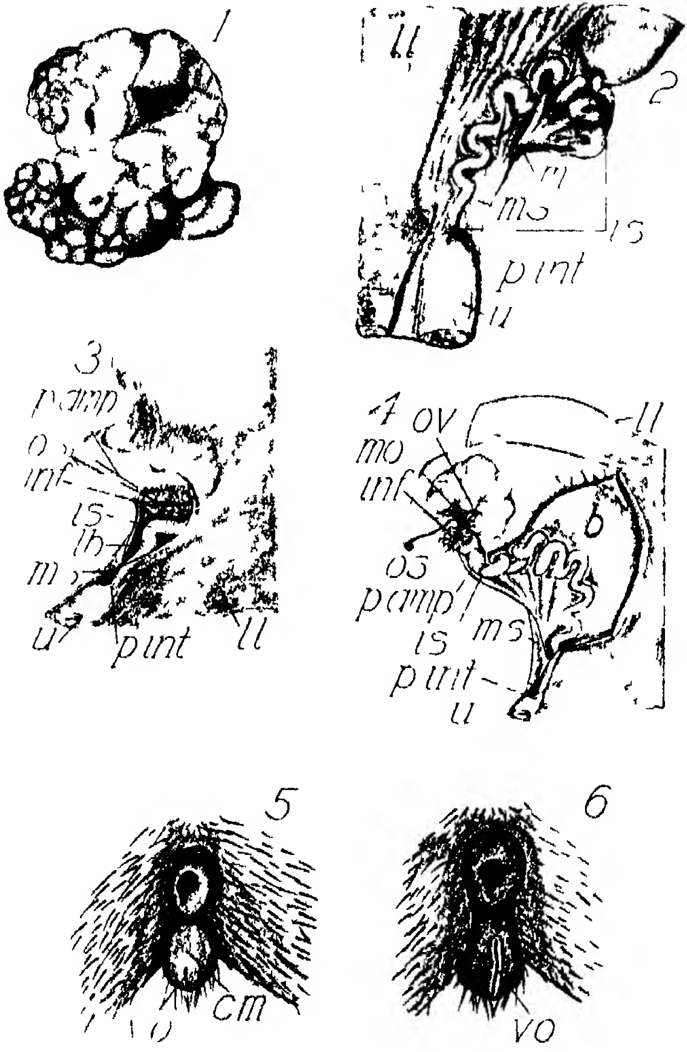
FIG 2 Transverse section of a uterine horn of animal 2821 taken during oestrum showing the great distention of the uterus by the copulation plug

FIG 3 Transverse section of a uterine horn of animal 2733 taken with two-cell embryos in the oviducts

FIG 4 Transverse section of a uterine horn of animal 2795 taken after the close of the reproductive period

FIG 5 Transverse section of the vagina of animal 2714 taken during oestrum

PLATE CXIII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KEY TO ABBREVIATIONS USED IN PLATES

b — ovarial bursa
c m — closure membrane
c p — copulation plug
gl — uterine glands
inf — infundibulum
is — isthmus
l — lumen of uterus
l b — lip of ovarial bursa
l l — ligamentum latum
m — mouth of ovarial bursa
m b — mesenterial border
mo — mesovarium
ms — mesosalpinx
musc — muscular coats
os — ostium
ov — ovary
p amp — pars ampullaris
p int — pars interstitialis
sm — submucosa
sm c — submuscular connective tissue
u — uterus
u l — uterine lumen
u m — uterine mucosa
ur — urethra
v e — vaginal epithelium
v l — vaginal lumen
v o — vaginal orifice

EXPLANATION OF PLATE CXIII

Fig 1 Ovary of animal 2881, a mature virgin taken before ovulation Follicles of various sizes are to be seen protruding on the surface of the ovary

Fig 2 Right oviduct and related parts of animal 28117, lateral view

Fig 3 Right ovarial bursa and related parts of animal 28117, medial view

Fig 4 Right ovary and related parts of animal 28117, medial view, wall of bursa opened

Fig 5 Vulva of a female taken before oestrum, showing small vaginal orifice and the closure membrane

Fig 6 Vulva of a female taken after oestrum, showing the large vaginal orifice and no closure membrane

ADDITIONAL DATA ON SUBMERGED DEPRESSION INDIVIDUALITY IN DOUGLAS LAKE, MICHIGAN *

PAUL S WELCH AND FRANK E EGGLETON

NUMEROUS data (Welch, 1928, Eggleton, 1931, Welch and Eggleton, 1932) have already been published on that distinct difference in limnological behavior which occurs in the six major, isolated, submerged depressions in the main basin of Douglas Lake, Cheboygan County, Michigan General characteristics of this depression individuality have also been summarized in the papers referred to above and need not be repeated here The very scant attention given to this phenomenon by other limnologists, the striking diversity of behavior of these depressions, the important bearing of the depression individuality upon certain limnological practices, and the unusually favorable conditions within Douglas Lake for such a study have made it seem desirable to continue the investigation Since the last report was published physico-chemical data covering three summer seasons (1931–33) have been obtained These data form the basis of this paper, and certain ones selected from the total data are analyzed in the tables attached to this report Temperature records were taken with a Negretti and Zambra reversing thermometer at vertical intervals of one meter Hydrogen ion concentration was determined by means of a LaMotte colorimeter, in which the intervals between standards are 0 2 pH Occasional use was also made of other methods of measuring hydrogen ion concentration, both electrometric and colorimetric Analyses of dissolved oxygen, free CO_2, and alkalinity were made according to procedures outlined in the well-known *Standard Methods of Water Analysis* Water samples for chemical analyses were taken at all

* Contribution from the University of Michigan Biological Station and from the Zoölogical Laboratory of the University of Michigan

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critical levels and at frequent intervals in all significant regions Maps of Douglas Lake indicating the position, size, and form of the isolated, submerged depressions appear in two of the earlier papers (Welch, 1928, Eggleton, 1931) and should be consulted in connection with these discussions The tabular matter (Tables I II) has been cast into essentially the same form as that of the previous reports in order that comparisons may be facilitated The data included in this report are restricted to physico-chemical features

THERMAL CONDITIONS

Thermal stratification — During the three seasons covered by this report all of the six major depressions, with one exception, developed typical thermal stratification with the characteristic formation of a thermocline The one exception (Stony Point depression) showed thermal stratification during two of the three seasons, but lacked it for most of the other summer Comparison with the previously published reports will show that thermal stratification was a more constant feature for the seasons of 1931–33 than in some other periods, also that while consistent differences in the position and form of the thermocline usually occurred in the various depressions on the same or adjacent similar dates, the differences were not so great as were manifested during some of the previous periods

During these three seasons the position and extent of the thermocline in South Fish-Tail, Roberts Point, and Fairy Island depressions were quite similar, although in previous seasons striking differences often occurred The meteorological uniformity of these three summers must not be stressed too much in trying to explain this rough agreement of the three depressions, since the other three depressions showed wide deviations However, similarity of thermocline was not accompanied by similarity of bottom temperatures (Table I)

Bottom-water temperatures — Table I shows differences, sometimes striking, in the bottom-water temperatures of the depressions, even though certain depressions are of the same depth and are located side by side South Fish-Tail depression, having the greatest protection, consistently maintains the lowest bottom temperatures The highest temperatures appear in Stony Point depression, since it has a maximum depth of only eighteen meters, which is barely sufficient to develop thermal stratification part of the time It is clear that each depression maintains its own bottom-water tempera-

ture and that these temperatures differ from one another, in some instances by several degrees Table I also indicates how these bottom-water temperatures differ in the different summers

Further confirmation of the increases in bottom-water temperature with the passing of the summer appears in the data given in Table I Some discussion of this gain in heat appears in the first report (Welch, 1928) While this increase in temperature is the rule in all the depressions, from time to time there is an absence of any significant change, as for example, in the Sedge Point depression in 1931 and in the Grapevine Point and Fairy Island depressions during 1932 Increase in temperature is greatest in Stony Point depression owing to the fact that this depression is not deep enough to maintain uninterruptedly its thermal stratification, and summer circulation of the water in the entire depression may be sufficient to mix some of the upper, warmer water with that at the bottom In the five deepest depressions where the thermal stratification, once it is established, is continuous for the season, this increase in temperature commonly does not exceed 1 0 degree C by the middle of August, although exceptions occur and the records for former years show gains as high as 3 0 degrees Opportunities for consistently following these temperature changes in the bottom waters until the initiation of the autumnal overturn have been lacking, but a few records made in late October show a continuous increase in temperature up to that time or later in South Fish-Tail depression However, one record made on October 20, 1928 (Eggleton, 1931) reveals that in the Roberts Point depression the bottom-water temperature had begun to fall Similar gains in bottom-water temperatures have been reported by Birge, Juday, and March, 1928, for Lake Mendota, Wisconsin, by Eggleton, 1931, for Third Sister Lake, Washtenaw County, Michigan, and by others

Peculiar deviations from the usual course of events occur in the temperature of the bottom waters from time to time, one of which is the occasional *decrease* in temperature For example, the temperature at the bottom of the South Fish-Tail depression on July 16, 1932, was 9 1 degrees, on August 5 it had dropped to 8 3 degrees During essentially the same period of the same year a similar but somewhat smaller decline occurred in the Sedge Point and Grapevine Point depressions (Table I) Records for earlier years also show an occasional decline of temperature of a similar sort

CHEMICAL CONDITIONS

Table II presents the principal chemical features for the past three summers Evidence of submerged depression individuality resides mostly in the records of dissolved oxygen, of free carbon dioxide, and of hydrogen ion concentration Alkalinity records show differences of such small magnitude that their significance is uncertain Since, during the period covered by this report, none of the deepest depressions lacked thermal stratification, the chemical stratification, for the most part, corresponds rather closely with the thermal stratification and yields additional evidence of depression individuality The various features of the chemical conditions have been discussed in the previous reports, and it scarcely seems necessary to continue them further at this time since, though additional confirmation is presented, nothing essentially new is involved

DISCUSSION

While the second report (Welch and Eggleton, 1932) was in press, two papers reporting submerged depression individuality appeared and could be referred to at that time only in footnotes added to the proof These papers deserve further attention

Scott (1931) mapped and described James Lake, Indiana, which goes well toward the extreme in complexity of basin It is quite elongated and is divided into three major portions arranged more or less in linear sequence and connected by narrows or channels, one being 242 meters wide and 8 2 meters deep, the other, 152 meters wide and about 9 meters deep Snow Lake, closely connected into this chain, is regarded by Scott as really being a fourth portion of James Lake, although the connection is longer, narrower, and shallower than those between the other major parts The four major portions of the lake contain twenty-one isolated, submerged depressions within the main basin These depressions were found to differ from one another physically, chemically, and biologically Differences in bottom-water temperatures in depressions having the same depth, differences in date of stratification, differences in the distribution of dissolved oxygen, and differences in the quality and quantity of the plankton are among the evidences of depression individuality which are recorded The division of this lake into three (or four) major portions connected by narrows might suggest

that these portions are essentially different lakes, each with individual differences However, it should be noted that the narrows are quite wide and have substantial depths In addition, each of these major portions ("basins") has several isolated, submerged depressions, and Scott's data show distinct individuality in the depressions within the same major portion of the lake

Yoshimura (1931) made observations upon Lake Akimoto, Japan, which also has a complex basin with isolated submerged depressions It is difficult to understand the details of this lake basin from Yoshimura's figure and very brief description, but it appears that the complexity of the main basin is the result of a volcanic mud flow which dammed the valley of two converging rivers in such a way that a lake was formed Within this lake additional deeply hollowed basins, separated from the main basin by submerged ridges, were formed from the valleys of small tributaries which entered above the mud dam The eight depressions vary in depth from 10 to 31 5 meters Of the deeper ones only two have similar depths Yoshimura found certain differences in temperature, dissolved oxygen, and hydrogen ion concentration between some depressions, also suggestions of biological difference Depression individuality was probably inevitable from the peculiar history of the lake basin, since it was formed by the drowning of several valleys probably of diverse character Each of the eight depressions appears, from Yoshimura's map, to have its own inflowing river or mountain brook In one sense these "basins" are not strictly comparable with one another, as are the depressions in Douglas Lake and at least some of the depressions in James Lake However, the fact remains that one kind of depression individuality exists in these "basins" which now are covered by one continuous surface stratum of water

Douglas Lake is particularly favorable for this kind of investigation since all the submerged depressions are within one wide-open lake basin, none of them are separated from others by narrows, and only one has any shore-line protection Some of them are of the same depth and very similar in size and form Depression individuality under these circumstances is particularly significant Further work on the biological aspect of this individuality is in progress and will be reported upon at a later time

SUMMARY

1 Physico-chemical data on Douglas Lake, Michigan, taken during three summer seasons (1931–33) are added to those already published

2 These data constitute further confirmation of that individuality of limnological behavior which is a constant feature of the submerged depressions within the main basin of this lake

3 Depression individuality during the past three summers, while not so pronounced as during some of the preceding summers, was, nevertheless, clearly present

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TABLE I

SUMMARY OF THERMAL STRATIFICATION IN DIFFERENT DEPRESSIONS

Temperatures expressed in degrees Centigrade thickness of epilimnion and hypolimnion and limits of thermocline stated in meters. Secondary thermoclines omitted

Date	Temperature		Epilimnion		Thermocline		Hypolimnion	
	Surface	Bottom	Thickness	Fall in temp	Limits	Fall in temp	Thickness	Fall in temp
SOUTH FISH TAIL DEPRESSION (Maximum depth 24 meters)								
1931								
July 2	27 0	6 8	11	9 2	11–15	8 6	9	2 4
July 14	23.5	6.8	10	4 2	10–16	11 3	8	1 2
July 27	23 4	6.8	11	2.8	1 -16	11 7	8	2 1
Aug. 5	22 4	7 0	11	1 8	11–16	12 5	8	1 1
1932								
July 1	19.8	8 1	11	1 4	11–16	9 0	8	1 3
July 6	19 4	9 0	13	1 8	13–16	6 9	8	1 7
July 16	20 9	9 1	13	2.9	13–16	7 4	8	1.5
Aug. 5	21.8	8.3	13	1 4	13–16	9 8	8	2 3
Aug. 21	21 6	8 4	14	1 6	14–17	10 2	6	1 5
1933								
July 3	23.8	8 0	12	6 6	12–15	7.8	8	1 4
July 21	24 0	8 0	9	2 7	9–16	10 9	8	2 4
Aug 20	22 0	8 4	13	2 8	13–16	9 0	8	1 8

TABLE I (*Continued*)

Date	Temperature		Epilimnion		Thermocline		Hypolimnion	
	Surface	Bottom	Thickness	Fall in temp	Limits	Fall in temp	Thickness	Fall in temp
SEDGE POINT DEPRESSION (Maximum depth, 24 meters)								
1931								
June 30	27.0	11.3	12	10.6	12–14	3.3	10	1.8
July 6	23.0	11.2	13	7.0	13–15	3.4	9	1.4
July 13	23.1	11.3	12	5.1	12–16	5.6	8	1.1
July 28	23.5	11.0	11	0.4	11–18	9.3	6	1.0
Aug. 13	22.4	11.3	14	1.9	14–17	8.7	7	0.5
1932								
July 5	19.7	12.0	13	2.0	13–15	3.7	9	2.0
July 19	24.6	13.3	13	4.2	13–16	4.9	8	2.3
Aug. 2	21.7	12.6	14	1.4	14–17	6.8	7	0.9
Aug. 21	21.7	12.6	15	1.7	15–17	6.2	7	1.2
1933								
June 30	25.2	11.1	15	8.5	15–17	3.7	7	1.9
July 20	22.8	11.1	15	6.2	15–18	4.7	6	0.8
Aug. 20	22.9	11.8	15	3.6	15–17	6.8	7	1.4
GRAPEVINE POINT DEPRESSION (Maximum depth 25 meters)								
1931								
June 30	25.4	11.6	11	7.4	11–14	4.7	11	1.7
July 6	22.0	11.6	10	3.5	10–15	6.2	10	0.7
July 13	22.5	11.6	10	3.1	10–15	7.0	10	0.8
July 21	24.1	12.0	10	2.9	10–16	8.1	9	1.1
July 28	23.5	12.1	12	1.2	12–17	9.4	8	0.8
Aug 13	21.7	12.3	15	2.1	15–17	6.6	8	0.7
1932								
June 30	20.3	13.3	11	1.9	11–13	4.2	12	0.9
July 19	23.6	13.3	14	3.4	14–18	6.2	7	0.7
Aug. 1	23.0	13.1	15	2.4	15–19	7.1	6	0.4
Aug. 21	20.8	13.3	18	1.2	18–20	6.1	5	0.2
1933								
June 29	26.5	10.7	12	9.3	12–15	5.2	10	1.3
July 21	23.5	10.9	10	3.9	10–14	6.6	11	2.1
Aug. 20	22.9	11.0	14	3.6	14–16	7.2	9	1.1

TABLE I (*Continued*)

Date	Temperature		Epilimnion		Thermocline		Hypolimnion	
	Surface	Bottom	Thickness	Fall in temp	Limits	Fall in temp	Thickness	Fall in temp
STONY POINT DEPRESSION (Maximum depth 18 meters)								
1931								
July 1	27.5	11.8	13	10.6	13–15	4.1	3	1.1
July 14	22.5	11.8	13	5.8	13–15	3.7	3	1.2
July 28	23.6	15.4	12	2.6	12–14	3.2	4	2.4
Aug 13	22.0	15.2	16	1.6	16–18	5.2	0	0.0
1932								
July 5	19.7	16.0	17	2.4	17–18	1.3	0	0.0
July 18	22.4	18.1			No stratification			
Aug. 1	22.5	20.3			No stratification			
Aug 21	21.8	19.8			No stratification			
1933								
June 30	24.8	13.9			No stratification			
July 20	22.6	15.4	9	1.1	9–10	2.5	8	3.6
Aug 20	21.0	17.2	17	1.5	17–18	1.3	0	0.0
ROBERTS POINT DEPRESSION (Maximum depth 22 meters)								
1931								
July 2	25.5	10.7	10	7.5	10–15	6.5	7	0.8
July 14	22.4	10.8	9	2.1	9–14	7.9	8	1.6
July 28	23.3	11.0	9	1.3	9–13	7.8	9	3.2
Aug 12	21.4	11.2	12	1.2	12–15	7.6	7	1.4
1932								
June 30	21.2	10.6	10	2.4	10–13	5.6	9	2.6
July 18	21.8	11.3	12	1.3	12–15	7.7	7	1.5
Aug 1	23.1	11.2	13	1.9	13–17	8.4	5	0.6
Aug. 21	20.5	11.5	15	1.5	15–17	6.2	5	1.3
1933								
June 29	26.5	10.1	11	9.9	11–15	5.4	7	1.1
July 21	23.5	10.1	8	1.9	8–13	8.9	9	2.6
Aug 20	20.6	10.3	12	2.2	12–14	5.8	8	2.3

TABLE I (*Concluded*)

Date	Temperature		Epilimnion		Thermocline		Hypolimnion	
	Surface	Bottom	Thickness	Fall in temp	Limits	Fall in temp	Thickness	Fall in temp
FAIRY ISLAND DEPRESSION (Maximum depth 28 meters)								
1931								
July 1	27.0	10.0	11	9.7	11–14	4.9	14	2.4
July 14	22.4	10.2	10	3.7	10–15	7.1	13	2.4
July 27	23.0	10.3	10	1.9	10–15	8.9	13	1.9
Aug. 10	21.5	10.5	12	1.0	12–15	7.9	13	2.1
1932								
June 30	21.0	11.7	10	3.0	10–13	3.9	15	2.4
July 18	21.3	11.6	12	1.3	12–16	7.0	12	1.4
Aug 1	22.0	11.7	13	2.1	13–16	7.1	12	1.1
Aug. 21	20.3	11.5	15	1.3	15–17	6.2	11	1.3
1933								
June 29	25.2	10.0	12	9.8	12–14	3.7	14	1.7
July 20	23.5	10.0	9	3.2	9–15	8.9	13	1.4
Aug. 17	20.7	10.3	11	0.1	11–15	9.0	13	1.3
Aug. 20	20.1	10.2	12	1.0	12–15	7.5	13	1.4

TABLE II

Summary of Chemical Analyses

Abbreviations t.s. thermal stratification unf. approximately uniform from surface to bottom c.s. chemical stratification c.gr., chemical gradient (gradual quantitative change in chemical features from surface to bottom) (e) estimated (value interpolated from nearest values since no record was available at exact thermocline limits

Dissolved oxygen expressed in cubic centimeters per liter free carbon dioxide in parts per million and methyl-orange alkalinity in parts per million of calcium carbonate In column for methyl-orange alkalinity the first number is for surface water and the second is for bottom water In column for oxygenless zone limits are expressed in meters the first number representing upper limit of oxygenless water and the second number bottom when the numbers are the same total absence of dissolved oxygen occurred only at bottom level

For details of corresponding thermal relations refer to Table I

Date	Temperature conditions	Chemical conditions	Dissolved Oxygen			Free CO		Methyl-orange alkalinity	pH	
			Surface and bottom	Thermocline	Oxygenless zone	Surface and bottom	Thermocline		Surface and bottom	Thermocline
SOUTH FISH TAIL DEPRESSION										
1931										
July 2	t.s.	c.s.	5.65–0.0	4.67–1.53	20(e)–24	0.0–7.0	5.0–6.0	129–137	8.3–7.0	7.1–7.0
July 14	t.s.	c.s.	5.96–0.0	5.30–0.27	20(e)–24	0.0–6.0	0.0–6.0	130–134	8.3–7.0	8.0–7.0
July 27	t.s.	c.s.	6.07–0.0	4.74–0.34	20–24	0.0–10.0	0.0–0.8	127–133	8.3–7.0	7.8(e)–7.0
Aug 5	t.s.	c.s.	6.00–0.0	5.58–0.01	17(e)–24	0.0–10.0	0.0–7.0(e)	130–132	8.3–7.0	8.2–7.0(e)
1932										
July 1	t.s.	c.s.	5.93–0.0	5.0(e)–2.16	22–24	0.0–11.0	0.0–3.0	128–142	8.4–7.0	8.1–7.4
July 6	t.s.	c.s.	5.79–0.0	5.17–2.65	22–24	0.0–10.0	0.0–2.5	129–144	8.4–7.0	8.0–7.4
July 16	t.s.	c.s.	5.65–0.0	5.09–1.53	20–24	0.0–10.0	0.5–3.0	130–138	8.4–7.0	8.0–7.3
Aug 5	t.s.	c.s.	5.93–0.0	5.03–4.12	20–24	0.0–10.0	0.0–4.0	128–139	8.3–7.0	8.2–7.7
Aug 21	t.s.	c.s.	5.79–0.0	4.25–3.83	22–24	0.0–10.0	0.0–6.0	128–138	8.3–7.0	8.2–7.2
1933										
July 3	t.s.	c.gr.	5.86–0.55	3.62–2.09(e)	absent	0.0–6.0	1.0–4.0(e)	129–132	8.4–7.1	7.9–7.3(e)
July 21	t.s.	c.s. (*)	5.72–0.0	5.44–1.25	22–24	0.0–8.0	0.0–6.0	129–132	8.4–7.1	8.4–7.3
Aug. 20	t.s.	c.s.	6.00–0.0	5.51–1.74(e)	20–24	0.0–11.0	0.0–7.0(e)	128–132	8.5–7.0	8.4–7.2(e)

TABLE II (*Continued*)

Date	Temperature conditions	Chemical conditions	Dissolved oxygen: Surface and bottom	Dissolved oxygen: Thermocline	Dissolved oxygen: Oxygenless zone	Free CO_2: Surface and bottom	Free CO_2: Thermocline	Methyl-orange alkalinity	pH: Surface and bottom	pH: Thermocline
					SEDGE POINT DEPRESSION					
1931										
June 30	t.s.	c.s.	5.44–0.20	2.30–2.02	absent	0.0–6.0	1.5–2.5	130–137	8.3–7.1	7.4–7.3
July 6	t.s.	c.s.	5.51–0.03	1.6(e)–1.0(e)	absent	0.0–6.0	4.0–5.0	130–135	8.3–7.0	7.3(e)–7.2(e)
July 13	t.s.	c.s.	5.79–0.03	1.60–0.16	absent	0.0–6.0(e)	3.0–5.0	130–133	8.3–7.1	7.3–7.1
July 28	t.s.	c.s.	6.07–0.0	5.72–0.34	20–24	0.0–8.0	0.0–6.0	124–138	8.3–7.1	8.2–7.2
Aug. 13	t.s.	c.s.	6.21–0.0	1.25–0.0	15–24	0.0–9.0	0.0–5.0	126–134	8.3–7.0	8.1–7.1
1932										
July 5	t.s	c.s (?)	5.93–0.0	4.0(e)–2.30	22–24	0.0–2.5	0.5–1.5	130–139	8.4–7.1	7.8–7.3
July 19	t.s.	c.s.	5.86–0.0	3.69–1.25	22(e)–24	0.0–11.0	0.0–0.7	130–139	8.4–7.0	8.0–7.2
Aug. 2	t.s.	c.s.	5.93–0.0	4.88–0.83	21(e)–24	0.0–12.0	0.0–5.0	128–146	8.3–7.0	8.2–7.2
Aug. 21	t.s.	c.s	5.86–0.0	5.16–1.46	19–24	0.0–10.0	0.0–3.0	127–139	8.3–7.0	8.3–7.5
1933										
June 30	t.s.	c.s.	5.44–0.13	2.58–0.27	absent	0.0–6.0	2.0–5.0	129–132	8.4–7.1	7.6–7.2
July 20	t.s.	c.s.	5.58–0.0	0.0–0.0	15–24	0.0–7.0	5.0–6.0	129–131	8.4–7.1	7.3–7.2
Aug. 20	t.s.	c.s.	6.07–0.0	4.46–0.41	20–24	0.0–(?)	0.0–6.0	127–131	8.5–7.1	8.4–7.4
					GRAPEVINE POINT DEPRESSION					
1931										
June 30	t.s.	c.gr	5.58–0.55	3.76–2.0(e)	absent	0.0–6.0	0.5–4.0(e)	130–135	8.3–7.1	7.9–7.4
July 6	t.s.	c.gr	5.65–0.34	4.25–1.95(e)	absent	0.0–6.0	0.5–4.5(e)	130–134	8.3–7.0	7.8–7.2(e)
July 13	t.s.	c.s.	5.93–0.0	5.09–1.53	20–25	0.0–6.0	0.0–5.0	130–133	8.3–7.1	8.0–7.1
July 28	t.s.	c.s.	5.93–0.0	2.44–0.06(e)	18–25	0.0–7.0	4.0–6.0(e)	126–139	8.3–7.2	7.4–7.2
Aug. 13	t.s.	c.s.	6.28–0.0	4.53–0.0	17–25	0.0–7.0	0.0–5.0	126–132	8.3–7.1	8.0–7.1
1932										
June 30	t.s.	c.gr (?)				0.0–10.0	0.5–4.0		8.4–7.1	7.8–7.3
July 19	t.s.	c.s.	5.86–0.0	5.02–2.09	22–25	0.0–11.0	0.0–6.0	131–140	8.4–7.1	8.1–7.2
Aug. 1	t.s.	c.s.	5.72–0.0	4.88–0.03	22–25	0.0–9.0	0.0–5.0	127–138	8.3–7.1	8.2–7.3
Aug. 21	t.s.	c.s.	5.86–0.10	5.30–0.20	absent(?)	0.0–10.0	0.0–1.0	127–139	8.3–7.0	8.2–7.8
1933										
June 29	t.s.	c.s.	4.88–0.55	4.46–2.65	absent	0.0–5.0	0.0–0.2	130–132	8.4–7.2	8.0–7.6
July 21	t.s.	c.s.	5.72–0.0	4.5(e)–0.7(e)	18–25	0.0–9.0	0.0–8.0	129–132	8.4–7.2	8.2(e)–7.2
Aug. 20	t.s.	c.s.	5.86–0.0	5.51–0.0	16–25	0.0–10.0	0.0–2.0	128–132	8.5–7.1	8.4–7.8

TABLE II (Continued)

Date	Temperature conditions	Chemical conditions	Dissolved oxygen: Surface and bottom	Dissolved oxygen: Thermocline	Dissolved oxygen: Oxygenless zone	Free CO_2: Surface and bottom	Free CO_2: Thermocline	Methyl-orange alkalinity	pH: Surface and bottom	pH: Thermocline
STONY POINT DEPRESSION										
1931										
July 1	t.s.	c.gr.	5.58–0.48	3.0(e)–1.67	absent	0.0–5.0	1.0–4.0	130–133	8.3–7.2	7.5–7.3
July 14	t.s.	c.s.	5.72–0.41	4.32–0.83	absent	0.0–6.0	2.0–4.0	130–134	8.3–7.1	7.5–7.3
July 28	t.s.	c.s.	6.07–0.0	0.03–0.0	14(e)–18	0.0–6.0	5.0–0.5	128–135	8.3–7.2	7.3–7.2(e)
Aug 13	t.s.	c.s.	6.28–1.32	4.81–1.32	absent	0.0–4.0	0.0–4.0	127–130	8.3–7.2	8.0–7.2
1932										
July 5	t.s.	slight c.gr.	5.93–4.20	4.4(e)–4.2	absent	0.0–1.0	0.5–1.0	126–135	8.4–7.7	7.8(e)–7.7
July 18	slight t.gr.	slight c.gr.	5.93–3.00		absent	0.0–0.5		131–135	8.4–8.0	
Aug 1	slight t.gr.	almost unf.	5.96–4.74		absent	0.0–0.0		128–131	8.3–8.1	
Aug 21	almost unf.	almost unf.	5.72–4.60		absent	0.0–0.0		128–131	8.3–8.2	
1933										
June 30	t.gr.	c.s.	5.58–0.0		18–18	0.0–5.0		130–134	8.4–7.2	
July 20	t.s.	c.s.	5.30–0.13	5.02–4.5(e)	absent(?)	0.0–5.0	0.0–1.0	127–130	8.4–7.3	8.3–7.8
Aug. 20	t.s.	slight c.gr.	5.86–4.11		absent	0.0–0.5		129–130	8.5–8.0	
ROBERTS POINT DEPRESSION										
1931										
July 2	t.s.	c.gr.	5.65–0.97	4.81–2.93	absent	0.0–5.0	0.5–3.0	130–132	8.3–7.1	7.9–7.5
July 14	t.s.	c.s.	6.07–0.0	4.95(e)–1.60	20–22	0.0–6.0	0.5(e)–4.0	129–133	8.3–7.1	8.0(e)–7.3
July 28	t.s.	c.s.	6.07–0.0	5.37(e)–0.27	18–22	0.0–8.0	0.0–5.0	127–132	8.3–7.1	8.2–7.2
Aug 12	t.s.	c.s.	6.07–0.0	5.44–0.0(e)	15–22	0.0–9.0	0.0–5.0(e)	128–134	8.3–7.1	8.2–7.1(e)
1932										
June 30	t.s.	c.gr.				0.0–11.0	0.5–5.0		8.4–7.1	7.9–7.3
July 18	t.s.	c.s.	5.16–0.34	4.88–3.73	20–22	0.0–9.0	0.0–4.0	135–149	8.4–7.0	8.1–7.6
Aug 1	t.s.	c.s.	5.68–0.0	4.89–0.35	18(e)–22	0.0–9.0	0.0–5.0	129–133	8.4–7.1	8.2–7.3
Aug 21	t.s.	c.s.	5.86–0.0	3.14–1.20(e)	19(e)–22	0.0–9.0	0.0–3.0(e)	128–138	8.3–7.0	8.2–7.3(e)
1933										
June 29	t.s.	c.gr.	4.88–0.83	4.15–2.23	absent	0.0–5.0	0.5–0.4	124–130	8.4–7.2	7.9–7.3
July 21	t.s.	c.s.	5.65–0.0	5.37–1.60	21–22	0.0–10.0	0.0–5.0	128–132	8.4–7.0	8.4–7.3
Aug 20	t.s.	c.s.	6.0–0.0	3.76–2.5(e)	19–22	0.0–10.0	3.0–5.0	129–131	8.5–7.0	7.[illegible]–7.5

TABLE II (*Concluded*)

Date	Temperature conditions	Chemical conditions	Dissolved oxygen: Surface and bottom	Dissolved oxygen: Thermocline	Dissolved oxygen: Oxygenless zone	Free CO_2: Surface and bottom	Free CO_2: Thermocline	Methyl-orange alkalinity	pH: Surface and bottom	pH: Thermocline
FAIRY ISLAND DEPRESSION										
1931										
July 1	t.s	c.gr	5.37–0.20	4.88–4.60	absent	0.0–7.0	0.0–0.1	130–134	8.3–7.1	8.0–7.7
July 14	t.s	c.s.	5.86–0.0	3.62–0.83	20–28	0.0–6.0	1.5–4.0	130–133	8.3–7.1	7.6–7.2
July 27	t.s.	c.s.	5.65–0.0	4.74–0.69	20–28	0.0–8.0	0.0–5.0	127–132	8.3–7.1	8.2–7.2
Aug. 10	t.s.	c.s.	5.79–0.0	5.44–0.69	20–28	0.0–10.0	0.0–5.0	128–134	8.3–7.0	8.2–7.1
1932										
June 30	t.s.	c.gr (?)				0.0–12.0	1.0–6.0(e)		8.4–7.0	7.7–7.3(e)
July 18	t.s	c.s.	5.37–0.0	5.02–3.49	22(e)–28	0.0–10.0	0.0–2.0	130–138	8.4–7.0	8.2–7.6
Aug. 1	t.s	c.s.	5.51–0.0	4.67–3.90	21(e)–28	0.0–8.0	0.0–1.0	128–137	8.3–7.1	8.1–7.8
Aug. 21	t.s	c.s	5.79–0.0	5.09–2.0(e)	20–28	0.0–10.0	0.0–4.0(e)	128–139	8.3–7.0	8.2–7.5(e)
1933										
June 29	t.s	c.gr	5.02–0.0	3.3(e)–2.79	26–28	0.0–5.0	1.7–3.0	130–133	8.4–7.1	7.7(e)–7.4
July 20	t.s	c.s.	5.72–0.0	4.60–1.25	23–28	0.0–10.0	0.0–0.4	128–132	8.4–7.1	8.1–7.3
Aug. 17	t.s	c.s	5.86–0.0	5.09–1.04	20–28	0.0–10.0	0.0–6.0	129–131	8.5–7.0	8.3(e)–7.3
Aug. 20	t.s	c.s	6.00–0.0	4.88–0.69	20–28	0.0–11.0	0.0–5.0	128–132	8.5–7.0	8.4–7.3

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